5-24-10M

# TEXAS AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
W. B. BIZZELL, President

BULLETIN NO. 320 MARCH, 1924

DIVISION OF ANIMAL INDUSTRY

# THE INFLUENCE OF INDIVIDUALITY, AGE AND SEASON UPON THE WEIGHTS OF FLEECES PRODUCED BY ANGORA GOATS UNDER RANGE CONDITIONS.




B. YOUNGBLOOD, Director
COLLEGE STATION, BRAZOS COUNTY, TEXAS

# STATION STAFF†

**ADMINISTRATION:**

B. YOUNGBLOOD, M. S., Ph. D., *Director*
A. B. CONNER, M. S., *Vice-Director*
A. H. LEIDIGH, M. S., *Assistant Director*
CHAS. A. FELKER, *Chief Clerk*
A. S. WARE, *Secretary*
M. P. HOLLEMAN, JR., *Ass't. Chief Clerk*
J. M. SCHAEDEL, *Executive Assistant*

**VETERINARY SCIENCE:**

*M. FRANCIS, D. V. M., *Chief of Division*
H. SCHMIDT, D. V. M., *Veterinarian*
V. J. BRAUNER, D. V. M., *Veterinarian*

**CHEMISTRY:**

G. S. FRAPS, Ph. D., *Chief of Division; State Chemist*
S. E. ASBURY, M. S., *Assistant Chemist*
W. H. WALKER, *Assistant Chemist*
J. E. TEAGUE, B. S., *Assistant Chemist*
J. K. BLUM, B. S., *Assistant Chemist*
H. STANFORD, B. S., *Assistant Chemist*
K. KITSUTA, M. S., *Assistant Chemist*

**HORTICULTURE:**

A. T. POTTS, M. S., M. S. C., *Chief of Division; Citriculturist*

**ANIMAL INDUSTRY:**

J. M. JONES, A. M., *Chief of Division; Sheep and Goats*
J. L. LUSH, Ph. D., *Animal Husbandman, Animal Breeding*
G. R. WARREN, B. S., *Swine Husbandman*
R. M. SHERWOOD, B. S., *Poultry Husbandman*
J. J. HUNT, *Wool Grader*

**ENTOMOLOGY:**

F. L. THOMAS, Ph. D., *Chief of Division; State Entomologist*
H. J. REINHARD, B. S., *Entomologist; Cotton Insects*
H. B. PARKS, B. S., *Apiculturist* (San Antonio)
A. H. ALEX, B. S., *Queen Breeder* (San Antonio)
C. S. RUDE, B. S., *Chief Foul Brood Inspector*
W. R. JORDAN, B. S., *Apiary Inspector*

**AGRONOMY:**

E. B. REYNOLDS, M. S., *Chief of Division; Soil Fertility*
A. B. CONNER, M. S., *Agronomist, Grain Sorghums*
A. H. LEIDIGH, M. S., *Agronomist, Small Grains*
G. N. STROMAN, Ph. D., *Agronomist, Cotton Breeding*
C. H. MAHONEY, B. S., *Assistant in Cotton Breeding*

**PLANT PATHOLOGY AND PHYSIOLOGY:**

J. J. TAUBENHAUS, Ph. D., *Chief of Division*

**FARM AND RANCH ECONOMICS:**

L. P. GABBARD, M. S., *Chief of Division*
B. YOUNGBLOOD, M. S., Ph .D., *Farm and Ranch Economist*
V. L. CORY, M. S., *Grazing Research Botanist* (Sonora)
H. E. REA, B. S. *Assistant in Farm and Ranch Economics*

**SOIL SURVEY:**

**W. T. CARTER, *B. S., Chief of Division; Soil Surveyor*
H. W. HAWKER, *Soil Surveyor*
E. H. TEMPLIN, B. S., *Soil Surveyor*

**BOTANY:**

H. NESS, M. S., *Chief of Division*

**PUBLICATIONS:**

A. D. JACKSON, *Chief of Division*

**STATE APICULTURAL RESEARCH LABORATORY:**

(San Antonio, Bexar County)
H. B. PARKS, B. S., *Apiculturist in Charge*
A. H. ALEX, B. S., *Queen Breeder*

**MAIN STATION FARM:**

D. T. KILLOUGH, B. S., *Superintendent*

**FEED CONTROL SERVICE:**

B. YOUNGBLOOD, M. S., Ph. D., *Director*
F. D. FULLER, M. S., *Chief of Division*
S. D. PEARCE, *Secretary*
J. H. ROGERS, *Inspector*
W. H. WOOD, *Inspector*
J. D. PREWIT, B. S., *Inspector*
T. C. DAVIS B. S., *Inspector*
J. F. SCHULTZ, B. S., *Inspector*
G. M. Morris, B. S., *Inspector*

## SUBSTATIONS:

**No. 1, Beeville, Bee County:**
R. A. HALL, B. S., *Superintendent*

**No. 2, Troup, Smith County:**
W. S. HOTCHKISS, *Superintendent*

**No. 3, Angleton, Brazoria County:**
V. E. HAFNER, B. S., *Superintendent*

**No. 4, Beaumont, Jefferson County:**
R. H. WYCHE, B. S., *Superintendent*

**No. 5, Temple, Bell County:**
A. B. CRON, B. S., *Superintendent*

**No. 6, Denton, Denton County:**
P. B. DUNKLE, B. S., *Superintendent*

**No. 7, Spur, Dickens County:**
R. E. DICKSON, B. S., *Superintendent*

**No. 8, Lubbock, Lubbock County:**
R. E. KARPER, B. S., *Superintendent*

**No. 9, Balmorhea, Reeves County:**
J. J. BAYLES, B. S., *Superintendent*

**No. 10, College Station, Brazos County:**
(Feeding and Breeding substation)
G. R. WARREN, B. S., *Animal Husbandman in Charge; Swine Husbandman*
R. M. SHERWOOD, B. S, *Poultry Husbandman*
L. J. McCALL, *Farm Superintendent*

**No. 11, Nacogdoches, Nacogdoches County:**
G. T. McNESS, *Superintendent*

****No. 12, Chillicothe, Hardeman County:**
D. L. JONES, *Superintendent*

**No. 14, Sonora, Sutton-Edwards Counties:**
E. M. PETERS, B. S., *Superintendent*
D. H. BENNETT, D. V. M., *Veterinarian*
V. L. CORY, M. S., *Grazing Research Botanist*
O. L. CARPENTER, *Shepherd*

**No. 15, Llano Grande, Hidalgo County:**
W. H. FRIEND, B. S., *Superintendent*

## Teachers in the School of Agriculture carrying cooperative projects on the Station:

S. W. BILSING, *Professor of Entomology*
W. L. STANGEL, *Professor of Animal Husbandry (Hogs)*
F. A. BUECHEL, *Professor of Agricultural Economics*
G. W. ADRIANCE, *Associate Professor of Horticulture*
W. E. GARNETT, *Professor of Rural Sociology*
R. C. WHITE, *Associate Professor of Rural Sociology*
G. P. GROUT, *Professor of Dairy Husbandry*
H. V. GEIB, *Assistant Professor of Agronomy*
E. O. POLLOCK, *Assistant Professor of Agronomy*

---

†As of July 1, 1924.
*In cooperation with School of Veterinary Medicine.
**In cooperation with United States Department of Agriculture.

## SYNOPSIS

This Bulletin reports the results of a study of the weights of fleeces produced by nearly 1200 different Angora goats kept under range conditions on the ranch experiment station in Southwestern Texas.

The first part of this Bulletin is introductory and describes the goats and the conditions under which they were kept, and defines the words which are used with a special meaning in this Bulletin.

The second part of this Bulletin is concerned with the constancy of the individual fleece weights from one shearing to another. Upon this constancy depends the success of methods of culling for increased fleece weight. Fleece weights are found not to be as constant for Angora goats as they were for the sheep reported in Texas Bulletin No. 311. The average coefficient of correlation between the weights of fleeces produced by the same Angora goats at different shearings was $+.415 \pm .008$. The fall shearing when the goat is a year and a half old is the most reliable time for the culling of goats to increase the average fleece production of the flock.

The third part of this Bulletin is concerned with the influence of the age of the goat upon the weight of the fleece it produces, and with the influence of seasonal conditions upon the average weight of fleece produced by the flock. The female goat, like the female sheep, reaches its maximum fleece-production in the second year of its life. Wether goats may produce still heavier fleeces at later ages. The average weight of the fleeces of mohair is more strongly influenced by changes in seasonal conditions than is the average weight of the fleeces of wool. Fall fleeces of mohair are heavier than spring fleeces.

CONTENTS

Bulletin No. 320 March, 1924

# THE INFLUENCE OF INDIVIDUALITY, AGE, AND SEASON UPON THE WEIGHTS OF FLEECES PRODUCED BY ANGORA GOATS UNDER RANGE CONDITIONS

Jay L. Lush
J. M. Jones

## PART ONE

### INTRODUCTION

Angora goats are usually kept for one or more of three different purposes. The first is for the mohair which they produce, the second is to keep certain kinds of brush browsed so closely as either to kill it out in a few years or at least to hold it in check, while the third is for the production of meat for human consumption. For the first purpose they have no real competitors because the mohair which they produce is a peculiar fiber well suited to certain manufacturing purposes and poorly suited to others. To a very limited extent mohair competes with wool but on the whole the two fibers are fitted for different processes of manufacture and are made into different kinds of fabrics and supplement each other instead of competing with each other. For killing brush, Angora goats come into competition with other goats, especially in the southwestern parts of the United States where many common Mexican goats are used for that purpose. In the production of meat for human food the Angora goat comes into severe competition not only with the other goats but also with sheep. At present the meat of the goat, now known officially as "chevon", does not bring in a very large part of the total revenue derived from goats. When properly prepared it is really a very nutritious and palatable meat and deserves much wider use as a part of the average American dietary than it has hitherto received.

Thus it comes about that the Angora goat-raisers are much more dependent for their profits upon the quality and weight of the fleeces which they produce than the sheep-raisers are. The sheep-raiser derives a very considerable portion of his revenue from the sale of lambs and sheep for slaughter but the demand is very limited for the corresponding products of the goat-raiser and therefore the quality and weight of the fleeces which he produces are relatively more important to him. This point is well illustrated by the figures in the Yearbook of the United States Department of Agriculture for 1922, which show that the number of goats slaughtered annually under federal inspection from 1910 to 1922 inclusive was only about three per cent of the total number of goats in the United States at that time, while the number of sheep so slaughtered annually during the same period was more than twenty-five per cent of the entire sheep population. These facts will emphasize the importance of methods of breeding for increased mohair production and methods of handling goats so that they

will produce more and better mohair, since mohair is the main source of revenue for the goat-raiser at present.

The Angora goat is especially important to the agricultural interests of Texas because of the volume of the industry. The census of 1920 showed that one-half of the goats of the United States were within the borders of Texas and the even greater importance of the Angora in Texas was shown by the fact that about three-fourths of the mohair produced in the United States in the year preceding the census was produced in Texas. The Angora goats in Texas are nearly all in the Edwards Plateau region of Southwestern Texas.

Substation No. 14 of the Texas Agricultural Experiment Station is located near the town of Sonora, very nearly in the center of the Edwards Plateau, and was established primarily for the study of problems which affect the production of goats, sheep, and cattle under range conditions. From the very beginning of the work at this station methods of breeding and management which would increase the amount of mohair have been an object of study by the Experiment Station workers. This Bulletin presents an analysis of the weights recorded for individual fleeces, and presents the evidence as to how much fleece weight is influenced by the individuality and the age of the goat and how much by seasonal changes.

## MATERIAL STUDIED

The material upon which this study is based consists of the individual weights of the fleeces shorn from the foundation registered goats at Substation No. 7, Spur, Texas, in the spring of 1917 and the spring of 1918, and the individual weights of all fleeces shorn from both registered and grade goats at Substation No. 14, Sonora, Texas, from the fall of 1918 to the spring of 1923. The two shearings made at Substation No. 7 were of twelve months' growth of mohair, but after the goats were moved to Substation No. 14 shearing was done every six months in accordance with the general policy of the goat-raisers of that region. Therefore, the weights were taken at twelve different shearings consisting of two twelve-month spring shearings (1917 and 1918), and five six-month fall shearings (1918 to 1922), and five six-month spring shearings (1919 to 1923). The fall shearing of 1918 really consisted of only five months' growth of mohair in the case of the registered does, but was of six months' growth of mohair for the grade goats. The other nine six-month shearings varied less than ten days from an exact six months' growth of mohair in each. Thus it will be seen that these shearings cover a period of seven years' growth of mohair and therefore were subject to the possible influence of a number of extreme variations in seasonal conditions. Fleece weights were taken accurate to the nearest quarter of a pound but a slight psychological bias on the part of the weigher toward whole numbers was evidenced at one or two shearings by the excess of even and half pound weights over quarter and three-quarter-pound weights. Thus it is absolutely accurate to say that weights were always accurate within less than a half pound and nearly always accurate within a quarter of a pound.

The goats were run on the range under conditions typical of that region, which is to say that they were not given any feed except a little cottonseed cake at times when there was very little browse to be had, as in the latter part of the winters following drouthy seasons. They received no shelter except the natural shelter of the trees and brush and the protection of a shed during rainy weather immediately after shearing.

The registered goats were of various ages and were purchased from several different breeders. The term, "Foundation registered does," as used in the tables later in this Bulletin, signifies all the purchased registered does and also the registered does born at Substation No. 7 in 1917 and 1918 in the case of shearings when these were more than two years old. The grade does were purchased in three different lots from two different breeders. Grade does 1-51 and grade does 52-154 were nearly all of the same age, most of them having been born in 1916, but they were from different breeders and does 1-51 were distinctly superior to the other group as mohair-producers, and hence their records have been considered separately. Grade does 292-416 were purchased from the same breeder as does 1-51, but were a year younger, all or nearly all of them, having been born in 1917.

## DEFINITIONS

The weight of fleece which an Angora goat will produce is determined by many different influences but, so far as the practical breeder is concerned, these influences may be divided into three classes. In the first class are the permanent individual differences between the goats. In the second class are the influences which produce temporary effects and do not affect all of the goats equally. In the third class are influences which produce temporary effects but affect all of the goats equally.

*Individuality* is used in this Bulletin to include all the influences of the first class, that is, all the permanent differences between individuals. Individuality includes all of the differences in heredity and also some permanent differences produced by environment, such as, for instance, a severe stunting of a goat's growth due to its having lost its mother while very young.

The second class of influences includes all those which cause the fleece weights of one goat to vary at different shearings in a way in which the fleece weights of the other goats of the same age and sex, and of similar breeding do not vary. Some examples of this class of influences are pregnancy, the suckling of a kid, temporary illness.

*Season* is used in this Bulletin to include all influences of the third class except age. Most of these influences are climatic. Examples are the amount and distribution of rainfall, temperature, humidity, and abundance or scarcity of feed.

In the analysis of fleece-weight records, influences of age and season can be eliminated by considering only the weights of fleeces from goats which were of the same age and sex and were sheared at the same time and had been given the same treatment since their preceding shearing.

Differences found in the weight of fleece produced by two goats under such identical treatment must be due to influences of the first and second classes. It is very important to know how much of these differences is due to influences of the first class, that is, to permanent individual differences between the goats, because these differences are the raw material upon which selection can work. If the permanent individual differences in fleece weight are numerous and large, a decided increase in the average fleece weight of the flock can be secured by careful culling. If individuality is relatively unimportant in determining fleece weight, then culling will be of little use as a means of increasing the average fleece weight of the flock, no matter how carefully it is practiced.

Part II of this Bulletin gives the analysis of the importance of individuality as it was actually found among the goats owned by the Experiment Station, and Part III gives the analysis of the effect of age and season upon the weight of fleece.

# PART II

## THE INFLUENCE OF INDIVIDUALITY ON FLEECE WEIGHTS

### PREVIOUS STUDIES

So far as the authors know, this question has not been studied elsewhere in any detail although general statements referring to individual differences between goats are found in various bulletins on the subject of the Angora goat and indicate that the writers of those publications appreciated from practical experience that individuality was of some considerable importance.

Two detailed studies of this same question have been made on sheep and they will be referred to frequently in this Bulletin for comparison. The first one was reported in Bulletin No. 127 of the Wyoming Agricultural Experiment Station and concerned the weight of the scoured fleeces produced by twenty-nine Rambouillet wethers one year on the range and three years in the feed lot. The second detailed study was reported in Bulletin No. 311 of the Texas Agricultural Experiment Station and concerned the grease (or unscoured) weights of the fleeces produced by 12 Corriedale ewes and 492 Rambouillet sheep of different ages and sexes, each of which was sheared at least twice (some of them as many as seven times) between the spring of 1918 and the spring of 1923, at Substation No. 14. The results given in Bulletin No. 311 of the Texas Station are especially suitable for comparison with the results given in this Bulletin because the Rambouillet sheep and Angora goats were not only under the same climatic conditions and same general system of management but were actually run in the same pastures and therefore are comparable in every way except that the shearing was done at slightly different seasons of the year.

### METHOD OF STUDY

*The method of studying individuality* was to take all the goats of the same age and sex which were sheared at two different times and rank them in the order of the weight of the fleece which they produced at the first shearing and then see how nearly they would come to ranking in the same order according to the weights of their fleeces at the second shearing. The method used in doing this is known to mathematicians as the method of correlation and the number which expresses the result is known as the "coefficient of correlation." The coefficient of correlation is an abstract number which can never be less than minus one nor more than plus one. If the two rankings should be exactly the same, the coefficient of correlation would be plus one and we would say that the correlation was perfect. Of course in actual data that never happens because there are too many temporary causes of variation. If the two rankings had no relation to each other the coefficient of correlation would be zero, and we would say that there was no correlation and would know that the goat which sheared a heavy fleece one time was just as likely as not to shear a light fleece the next time. If the second ranking were

exactly opposite to the first the coefficient of correlation would be minus one, and we would say that there was perfect negative correlation, and we would know that the goat which sheared a heavy fleece one time was certain to shear a light fleece the next time.

As already stated, correlations in actual practice are never perfect and their importance is judged by their size. For most practical purposes (for instance, as a guide in selection), a correlation is of very little importance if its coefficient is less than .30 and is of very great importance if its coefficient is greater than .60. The importance of the correlation increases with the square of its coefficient and therefore the higher coefficients show correlations ever so much more important than the lower ones.

There were 302 different comparisons concerned in this study and of course it is impossible to show within the limits of this Bulletin every one of these correlation tables. However, three correlation tables are shown as samples in Figures 1 to 3. These three correlation tables were selected for the following reasons: Figure 1 shows the table including the largest number of individuals and is a representative table. Figure 2 shows the table which gives the highest of all correlations found and is therefore not a truly representative table. Figure 3 shows the table which gives the lowest of all correlations found and is therefore not a truly representative table.

Fleece Weight, Fall of 1918.

| Fleece Weight, Spring of 1919. | 1.00 | .25 | .50 | .75 | 2.00 | .25 | .50 | .75 | 3.00 | .25 | .50 | .75 | 4.00 | .25 | .50 | .75 | 5.00 | .25 | .50 | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | | | | | 1 | | | | | | | | | | | | | | | 1 |
| .25 | | | | | | | | | | | | | | | | | | | | 0 |
| .50 | | | | | 1 | | | | 1 | | 3 | | | | | | | | | 5 |
| .75 | | 1 | | | | 2 | | | | 1 | | | | | | | | | | 4 |
| 2.00 | | | | | | | | | 2 | | 3 | | | | | | | | | 5 |
| .25 | | | | | 1 | | 1 | | 2 | 2 | 2 | 1 | 2 | | | 1 | | | | 12 |
| .50 | | | | | 1 | 1 | 5 | 3 | | 3 | 3 | 1 | 1 | | | 2 | | 1 | | 21 |
| .75 | | | | | | 1 | | 1 | | 3 | 5 | | 5 | 1 | 1 | | | | | 17 |
| 3.00 | | | | | 1 | 1 | 1 | 1 | 1 | 3 | | 2 | 3 | 1 | 1 | | | | | 15 |
| .25 | | | | | | 1 | | | 1 | 4 | 3 | 4 | | | | | | | | 13 |
| .50 | | | | | | | | 1 | | 1 | 2 | 4 | | 1 | | | | | | 9 |
| .75 | | | | | | | | | | | | 2 | 2 | | | | | 1 | 1 | 6 |
| 4.00 | | | | | | | | | | | | 1 | | | 1 | | 1 | | | 3 |
| .25 | | | | | | 1 | | | | | | | 1 | | 1 | | | | | 3 |
| .50 | | | | | | | | | | | | | | | 2 | | | | | 2 |
| .75 | | | | | | | | | | | | | | | | | | | | 0 |
| 5.00 | | | | | | | | | | | | | | | | | | | 1 | 1 |
| .25 | | | | | | | | | | | | | | | | | | | | |
| .50 | | | | | | | | | | | | | | | | | | | | |
| Totals | 1 | 0 | 4 | 8 | 7 | 6 | 7 | 17 | 21 | 15 | 14 | 3 | 6 | 3 | 1 | 2 | 2 | | | 117 |

1919:
Average = 2.64 lbs.
Standard Deviation = .710 lbs.
Coefficient of Variation = 25.1 %

1918:
Average = 3.45 lbs.
Standard Deviation = .782 lbs.
Coefficient of Variation = 22.7 %

Coefficient of Correlation = +.448 ± .050

Figure 1. Grade Angora Does, Nos. 292-416, most of them born in 1917. Correlation between the weights of the fleeces shorn in the fall of 1918 and in the spring of 1919.

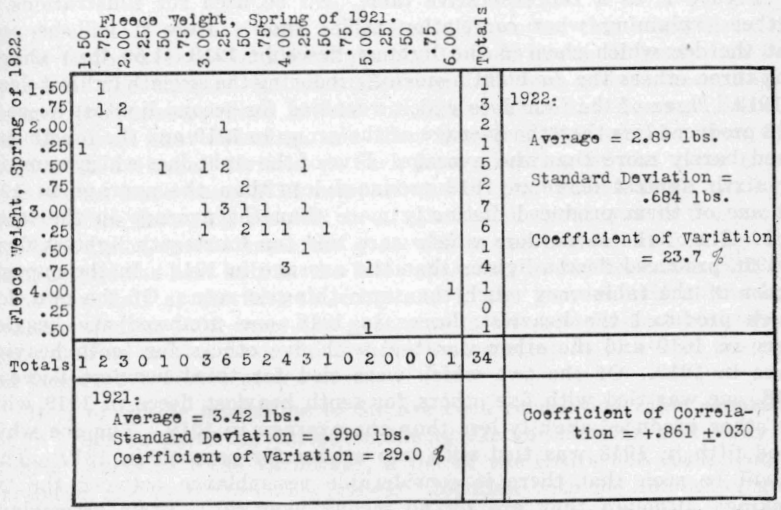


Figure 2. Grade Angora Does, Nos. 155-291, born in 1918. Correlation between the weights of the fleeces shorn in the spring of 1921 and those shorn in the spring of 1922.

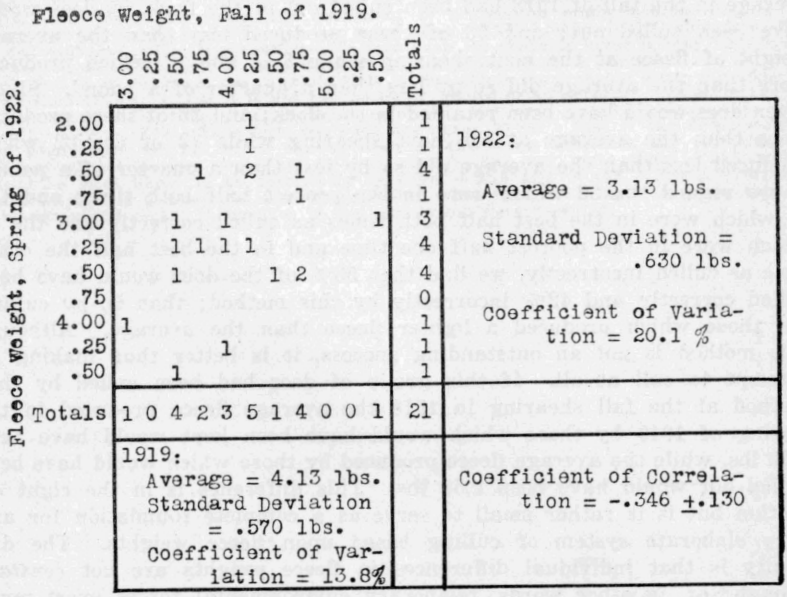


Figure 3. Grade Angora Does, Nos. 1-51, born in 1916 or earlier. Correlation between the weights of the fleeces shorn in the fall of 1919 and those shorn in the spring of 1922.

Figure 1, as a representative table, will be used for illustrations in further explaining what correlation tables show. Here it will be seen that the doe which sheared the lightest fleece in 1918 (1.50 lbs.) shared with three others the doubtful honor of producing the seventh lightest fleece in 1919. Three of the four does which were tied for second lightest fleece in 1918 produced less than the average of the group in 1919 and the fourth produced barely more than the average. Five of the eight does which were tied for sixth lightest fleece in 1918 produced less than the average in 1919 but one of them produced distinctly more than the average in the latter year. Six of the seven does which were tied for fourteenth lightest fleece in 1918 produced fleeces lighter than the average in 1919. In the opposite corner of the table very much the same thing is seen. Of the two does which produced the heaviest fleeces in 1918, one produced the heaviest fleece in 1919 and the other was tied with five others for tenth heaviest fleece in 1919. Of the two which were tied for third heaviest fleece in 1918, one was tied with five others for tenth heaviest fleece in 1919 while the other produced slightly less than the average in 1919. The doe which stood fifth in 1918 was tied with two others for seventh in 1919. Thus it will be seen that there is considerable resemblance between the two rankings although they are by no means identical. Their resemblance is not nearly so strong as it was in the case of the Rambouillet sheep described in Texas Bulletin No. 311.

If the does of the group in Figure 1 which sheared less than the average in the fall of 1918 had been culled out of the flock, 50 does would have been culled out; and 33 of these produced less than the average weight of fleece at the next shearing while 8 of the 17 which produced more than the average did so by less than a quarter of a pound. Sixty-seven does would have been retained in the flock; and 35 of these produced more than the average at the next shearing while 12 of the 32 which produced less than the average did so by less than a quarter of a pound. If we regard the 33 which were in the poorest half both times and the 35 which were in the best half both times as culled correctly and the 49 which were in the poorest half one time and in the best half the other time as culled incorrectly, we find that 58% of the does would have been culled correctly and 42% incorrectly by this method; that is, by culling out those which produced a lighter fleece than the average. Although this method is not an outstanding success, it is better than making no attempt to cull at all. If this group of does had been culled by that method at the fall shearing in 1918 the average fleece produced in the Spring of 1919 by those which would have been kept would have been 3.02 lbs. while the average fleece produced by those which would have been culled out would have been 2.59 lbs. This difference is in the right direction but is is rather small to serve as a complete foundation for any very elaborate system of culling based upon fleece weights. The difficulty is that individual differences in fleece weights are not *constant* enough; or, in other words, temporary environmental forces exert much more influence over fleece weight than individuality does.

In the discussion in the preceding paragraph only the two shear-

ings shown in Figure 1 were considered. However, this same discussion applies to the average of all the goats. If each group of goats had been divided at the time of its first shearing into two groups according to whether their fleeces were heavier or lighter than the average fleece of their group at that shearing, and then this first division had been compared with a similar division at each later shearing of the same group, there would have been 3712 comparisons of two fleeces from the same goat with the following results: in 1180 cases the goat was in the poorest half both times, in 694 cases the goat was in the poorest half at the first shearing and the best half at the later shearing, in 736 cases the goat was in the best half at the first shearing and in the poorest half at the later shearing, and in 1102 cases the goat was in the best half at both shearings. Culling on this basis would have been correct in 61.5% of the cases and incorrect in 38.5% of the cases.

It is of course impossible to discuss each correlation table separately but in order to show the variation among the correlations and study the possible causes of these variations, a list of the entire 302 coefficients of correlation and their "probable errors,"* together with the number of goats included in each is given in Table 1.

*"Probable error" is a term used by mathematicians to show how likely it is that the same results will be obtained if the experiment is repeated under the same conditions. For example the coefficient of correlation for Figure 1 is $+.448 \pm .050$. This means that if another 117 does of the same age and breeding had had their fleeces weighed during the same two years, the coefficient of correlation might not be exactly the same but it would probably not be more than $+.448+.050=+.498$, nor less than $+.448-.050=+.398$. If a coefficient is less than its probable error it may very easily be the result of chance; if it is three times its probable error the odds are about 22 to 1 that it is not an accident, while if it is five times its probable error the odds are more than 1350 to 1 that it is not the result of chance or an accident. Thus, in the example used, three times the probable error is .150 and $+.488+.150=+.598$ while $+.448-.150=+.298$. Therefore, the odds are about 22 to 1 that if the fleece weights had been taken on 117 other similar does at the same shearings the resulting coefficient of correlation would not be less than $+.298$ nor more than $+.598$ and it would be most likely to be somewhere between $+.398$ and $+.498$. Probable error is therefore merely a means of measuring within what limits the facts found in this experiment would repeat themselves if the experiment were repeated.

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings

(Coefficients of correlations are positive except where otherwise indicated)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| Grade Does 1-51, born in 1916, purchased. (Includes 46 different does which were sheared at least twice) | | |
| Fall of 1918 and Spring of 1919 | 44 | .467±.080 |
| Fall of 1919 | 39 | .494±.082 |
| Spring of 1920 | 31 | .509±.090 |
| Fall of 1920 | 38 | .530±.079 |
| Spring of 1921 | 34 | .239±.109 |
| Fall of 1921 | 23 | .084±.140 |
| Spring of 1922 | 22 | —.148±.141 |
| Spring of 1919 and Fall of 1919 | 41 | .267±.098 |
| Spring of 1920 | 33 | .638±.070 |
| Fall of 1920 | 40 | .273±.099 |
| Spring of 1921 | 35 | .458±.090 |
| Fall of 1921 | 23 | .027±.141 |
| Spring of 1922 | 22 | .317±.129 |
| Fall of 1919 and Spring of 1920 | 31 | .300±.110 |
| Fall of 1920 | 38 | .429±.089 |
| Spring of 1921 | 33 | .203±.110 |
| Fall of 1921 | 22 | —.060±.143 |
| Spring of 1922 | 21 | —.346±.130 |
| Spring of 1920 and Fall of 1920 | 32 | .439±.096 |
| Spring of 1921 | 28 | .804±.045 |
| Fall of 1921 | 17 | .507±.122 |
| Spring of 1922 | 16 | .651±.097 |
| Fall of 1920 and Spring of 1921 | 34 | .364±.100 |
| Fall of 1921 | 22 | —.079±.143 |
| Spring of 1922 | 21 | —.115±.145 |
| Spring of 1921 and Fall of 1921 | 23 | .636±.084 |
| Spring of 1922 | 22 | .630±.087 |
| Fall of 1921 and Spring of 1922 | 22 | .193±.139 |
| Average of 28 correlations for grade does 1-51 | | +.311±.036 |
| Grade does 52-154 born in 1916 or earlier, mostly older, purchased. (Includes a total of 89 different does which were sheared at least twice) | | |
| Fall of 1918 and Spring of 1919 | 85 | .469±.057 |
| Fall of 1919 | 81 | .568±.051 |
| Spring of 1920 | 25 | .545±.095 |
| Fall of 1920 | 32 | .620±.073 |
| Spring of 1921 | 27 | .495±.098 |
| Spring of 1919 and Fall of 1919 | 85 | .526±.053 |
| Spring of 1920 | 25 | .739±.061 |
| Fall of 1920 | 33 | .504±.088 |
| Spring of 1921 | 27 | .686±.069 |
| Fall of 1919 and Spring of 1920 | 25 | .485±.103 |
| Fall of 1920 | 33 | .590±.077 |
| Spring of 1921 | 27 | .448±.104 |
| Spring of 1920 and Fall of 1920 | 23 | .312±.127 |
| Spring of 1921 | 21 | .725±.070 |
| Fall of 1920 and Spring of 1921 | 26 | .449±.106 |
| Average of 15 correlations for grade does 52-154 | | +.544±.019 |
| Grade does 155-291, born at the Station in 1918 out of does 1-154 (Includes a total of 69 different does which were sheared at least twice) | | |
| Fall of 1918 and Spring of 1919 | 66 | .206±.080 |
| Fall of 1919 | 59 | .182±.085 |
| Spring of 1920 | 29 | .014±.125 |
| Fall of 1920 | 53 | .081±.092 |
| Spring of 1921 | 48 | .019±.097 |
| Fall of 1921 | 35 | —.065±.114 |

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings—(Continued)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| Spring of 1922 | 32 | —.214±.114 |
| Spring of 1919 and Fall of 1919 | 60 | .518±.064 |
| Spring of 1920 | 30 | .200±.118 |
| Fall of 1920 | 55 | .478±.070 |
| Spring of 1921 | 50 | .632±.057 |
| Fall of 1921 | 37 | .337±.098 |
| Spring of 1922 | 34 | .652±.067 |
| Fall of 1919 and Spring of 1920 | 29 | —.129±.123 |
| Fall of 1920 | 55 | .508±.068 |
| Spring of 1921 | 50 | .376±.082 |
| Fall of 1921 | 37 | .586±.073 |
| Spring of 1922 | 34 | .318±.104 |
| Spring of 1920 and Fall of 1920 | 27 | —.121±.128 |
| Spring of 1921 | 25 | .010±.135 |
| Fall of 1921 | 19 | .004±.155 |
| Spring of 1922 | 19 | .191±.149 |
| Fall of 1920 and Spring of 1921 | 49 | .361±.084 |
| Fall of 1921 | 36 | .436±.091 |
| Spring of 1922 | 33 | .265±.109 |
| Spring of 1921 and Fall of 1921 | 37 | .067±.110 |
| Spring of 1922 | 34 | .861±.030 |
| Fall of 1921 and Spring of 1922 | 34 | .195±.111 |
| Average of 28 correlations for grade does 155-291 | | .249±.034 |
| **Grade does 292-416, born in 1917, purchased. (Includes a total of 120 different does which were sheared at least twice)** | | |
| Fall of 1918 and Spring of 1919 | 117 | .448±.050 |
| Fall of 1919 | 112 | .495±.048 |
| Spring of 1920 | 69 | .318±.073 |
| Fall of 1920 | 108 | .561±.045 |
| Spring of 1921 | 96 | .472±.054 |
| Fall of 1921 | 48 | .406±.081 |
| Spring of 1922 | 48 | .331±.087 |
| Fall of 1922 | 12 | —.001±.195 |
| Spring of 1923 | 11 | .322±.182 |
| Spring of 1919 and Fall of 1919 | 113 | .396±.054 |
| Spring of 1920 | 71 | .564±.055 |
| Fall of 1920 | 109 | .456±.051 |
| Spring of 1921 | 97 | .619±.042 |
| Fall of 1921 | 49 | .281±.089 |
| Spring of 1922 | 49 | .250±.090 |
| Fall of 1922 | 12 | .074±.194 |
| Spring of 1923 | 11 | .074±.202 |
| Fall of 1919 and Spring of 1920 | 69 | .350±.071 |
| Fall of 1920 | 108 | .650±.038 |
| Spring of 1921 | 95 | .367±.060 |
| Fall of 1921 | 49 | .600±.062 |
| Spring of 1922 | 48 | .301±.089 |
| Fall of 1922 | 12 | .559±.134 |
| Spring of 1923 | 11 | .534±.145 |
| Spring of 1920 and Fall of 1920 | 69 | .427±.066 |
| Spring of 1921 | 60 | .659±.049 |
| Fall of 1921 | 33 | .418±.097 |
| Spring of 1922 | 32 | .114±.118 |
| Fall of 1922 | 9 | .501±.168 |
| Spring of 1923 | 9 | .675±.122 |
| Fall of 1920 and Spring of 1921 | 94 | .402±.058 |
| Fall of 1921 | 48 | .417±.081 |
| Spring of 1922 | 46 | .391±.083 |
| Fall of 1922 | 12 | .497±.147 |
| Spring of 1923 | 11 | .545±.142 |
| Spring of 1921 and Fall of 1921 | 46 | .321±.089 |
| Spring of 1922 | 45 | .394±.085 |
| Fall of 1922 | 11 | .556±.141 |
| Spring of 1923 | 10 | .685±.113 |
| Fall of 1921 and Spring of 1922 | 46 | .083±.099 |

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings—(Continued)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| Fall of 1922 | 10 | .476±.165 |
| Spring of 1923 | 9 | .536±.160 |
| Spring of 1922 and Fall of 1922 | 11 | .438±.164 |
| Spring of 1923 | 10 | .394±.180 |
| Fall of 1922 and Spring of 1923 | 11 | .716±.099 |
| Average of 45 correlations for grade does 292-416 | | .424±.017 |
| Grade does 418-684, born at the Station in the Spring of 1919 out of does 1-154 and 292-416. (Includes a total of 123 different does which were sheared at least twice) | | |
| Fall of 1919 and Spring of 1920 | 105 | .441±.053 |
| Fall of 1920 | 112 | .569±.043 |
| Spring of 1921 | 101 | .203±.064 |
| Fall of 1921 | 74 | .480±.060 |
| Spring of 1922 | 76 | .286±.071 |
| Fall of 1922 | 41 | .220±.100 |
| Spring of 1923 | 33 | .262±.109 |
| Spring of 1920 and Fall of 1920 | 108 | .520±.047 |
| Spring of 1921 | 96 | .572±.046 |
| Fall of 1921 | 73 | .400±.066 |
| Spring of 1922 | 74 | .418±.065 |
| Fall of 1922 | 41 | .298±.096 |
| Spring of 1923 | 33 | .470±.092 |
| Fall of 1920 and Spring of 1921 | 104 | .373±.057 |
| Fall of 1921 | 78 | .561±.052 |
| Spring of 1922 | 80 | .336±.067 |
| Fall of 1922 | 43 | .571±.069 |
| Spring of 1923 | 35 | .256±.107 |
| Spring of 1921 and Fall of 1921 | 76 | .270±.072 |
| Spring of 1922 | 78 | .564±.052 |
| Fall of 1922 | 43 | .382±.088 |
| Spring of 1923 | 35 | .620±.070 |
| Fall of 1921 and Spring of 1922 | 79 | .295±.069 |
| Fall of 1922 | 43 | .520±.075 |
| Spring of 1923 | 35 | .304±.104 |
| Spring of 1922 and Fall of 1922 | 43 | .264±.096 |
| Spring of 1923 | 35 | .534±.081 |
| Fall of 1922 and Spring of 1923 | 36 | .341±.099 |
| Average of 28 correlations for grade does 418-684 | | .405±.016 |
| Grade does 687-941, born at the Station in the Spring of 1920 out of does 1-416. (Includes a total of 78 different does which were sheared at least twice) | | |
| Fall of 1920 and Spring of 1921 | 73 | .518±.058 |
| Fall of 1921 | 65 | .562±.057 |
| Spring of 1922 | 64 | .493±.064 |
| Fall of 1922 | 41 | .543±.074 |
| Spring of 1923 | 35 | .550±.080 |
| Spring of 1921 and Fall of 1921 | 67 | .562±.056 |
| Spring of 1922 | 66 | .532±.060 |
| Fall of 1922 | 41 | .500±.079 |
| Spring of 1923 | 35 | .598±.073 |
| Fall of 1921 and Spring of 1922 | 67 | .481±.063 |
| Fall of 1922 | 43 | .538±.073 |
| Spring of 1923 | 37 | .617±.069 |
| Spring of 1922 and Fall of 1922 | 42 | .480±.080 |
| Spring of 1923 | 36 | .617±.070 |
| Fall of 1922 and Spring of 1923 | 37 | .540±.079 |
| Average of 15 correlations for grade does 687-941 | | .542±.007 |

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings—(Continued)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| Grade does 943-1141, born at the Station in the Spring of 1921 out of does 1-684 | | |
| Fall of 1921 and Spring of 1922 | 87 | .420±.060 |
| Spring of 1923 | 10 | .489±.163 |
| Grade does 1142-1178, born at the Station in the Spring of 1922 out of does 1-941. | | |
| Fall of 1922 and Spring of 1923 | 19 | .240±.146 |
| Average of 162 correlations of eight different groups of grade does, involving shearing records of 631 different individuals | | .392±.011 |
| Grade wethers 157-290, born at the station in the Spring of 1918 out of does 1-154. | | |
| (Includes a total of 47 different wethers which were sheared at least twice) | | |
| Fall of 1918 and Spring of 1919 | 44 | .400±.085 |
| Fall of 1919 | 42 | .465±.082 |
| Spring of 1920 | 42 | —.074±.104 |
| Fall of 1920 | 35 | .473±.089 |
| Spring of 1921 | 33 | —.084±.117 |
| Spring of 1919 and Fall of 1919 | 45 | .470±.078 |
| Spring of 1920 | 45 | .542±.071 |
| Fall of 1920 | 37 | .255±.104 |
| Spring of 1921 | 34 | .319±.104 |
| Fall of 1919 and Spring of 1920 | 44 | .263±.095 |
| Fall of 1920 | 36 | .664±.063 |
| Spring of 1921 | 33 | .412±.098 |
| Spring of 1920 and Fall of 1920 | 37 | .158±.108 |
| Spring of 1921 | 34 | .544±.082 |
| Fall of 1920 and Spring of 1921 | 33 | .078±.117 |
| Grade wethers 417-686, born at the station in the Spring of 1919 out of does 1-154 and 292-416 | | |
| (Includes a total of 119 different wethers which were sheared at least twice) | | |
| Fall of 1919 and Spring of 1920 | 114 | .436±.051 |
| Fall of 1920 | 106 | .585±.043 |
| Spring of 1921 | 93 | .143±.069 |
| Spring of 1920 and Fall of 1920 | 106 | .578±.044 |
| Spring of 1921 | 94 | .593±.045 |
| Fall of 1920 and Spring of 1921 | 95 | .459±.055 |
| Grade wethers 688-942, born at the Station in the Spring of 1920 out of does 1-416. | | |
| Fall of 1920 and Spring of 1921 | 70 | .545±.057 |
| Grade wethers 944-1139 born at the Station in the Spring of 1921 out of does 1-684. | | |
| Fall of 1921 and Spring of 1922 | 66 | .281±.077 |
| Grade wethers 1145-1179, born at the Station in the Spring of 1922 out of does 1-941 | | |
| Fall of 1922 and Spring of 1923 | 11 | .343±.180 |
| Average of 24 correlations on a total of five different groups of wethers involving shearing records from 313 different individuals | | .369±.028 |

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings—(Continued)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| Registered Angora Bucks, purchased or born in 1918 | | |
| Long Spring of 1919 and Fall of 1919 | 12 | .558±.134 |
| Registered bucks born at the Station in the Spring of 1920 (Includes a total of 18 different individuals which were sheared at least twice) | | |
| Fall of 1920 and Spring of 1921 | 14 | —.330±.161 |
| Long Spring of 1922 | 12 | .176±.189 |
| Spring of 1921 and Long Spring of 1922 | 16 | .365±.146 |
| Registered bucks born at the Station in the Spring of 1921. | | |
| Fall of 1921 and Spring of 1922 | 24 | .610±.087 |
| Registered bucks born at the Station in the Spring of 1922. | | |
| Fall of 1922 and Spring of 1923 | 13 | .150±.145 |
| Average of 6 correlations on 4 different groups of registered bucks involving shearing records from 67 different individuals | | .255±.086 |
| Foundation Registered Does, purchased from various sources, born in 1917 or earlier, most of them in 1915, and no shearing records used where the does were not at least eighteen months old. This also includes registered does born at the station in 1917 and 1918 but no shearing records of these before they were two and one-half years old were used. (66 different does are included). | | |
| Long Spring of 1917 and Long Spring of 1918 | 21 | .116±.145 |
| Fall of 1918 | 20 | .310±.136 |
| Spring of 1919 | 20 | .469±.118 |
| Fall of 1919 | 19 | .515±.114 |
| Spring of 1920 | 20 | .291±.138 |
| Fall of 1920 | 18 | .359±.138 |
| Spring of 1921 | 16 | —.025±.169 |
| Fall of 1921 | 16 | .282±.155 |
| Spring of 1922 | 15 | .253±.163 |
| Fall of 1922 | 16 | .265±.157 |
| Spring of 1923 | 11 | .190±.196 |
| Long Spring of 1918 and Fall of 1918 | 20 | .398±.127 |
| Spring of 1919 | 20 | .416±.125 |
| Fall of 1919 | 19 | .336±.137 |
| Spring of 1920 | 20 | .439±.122 |
| Fall of 1920 | 18 | .337±.141 |
| Spring of 1921 | 16 | .325±.151 |
| Fall of 1921 | 16 | .514±.124 |
| Spring of 1922 | 15 | .582±.115 |
| Fall of 1922 | 16 | .433±.137 |
| Spring of 1923 | 11 | .417±.168 |
| Fall of 1918 and Spring of 1919 | 52 | .444±.075 |
| Fall of 1919 | 48 | .301±.089 |
| Spring of 1920 | 51 | .344±.083 |
| Fall of 1920 | 48 | .308±.088 |
| Spring of 1921 | 46 | .243±.094 |
| Fall of 1921 | 44 | .366±.088 |
| Spring of 1922 | 43 | .562±.070 |
| Fall of 1922 | 45 | .323±.090 |
| Spring of 1923 | 34 | .183±.112 |
| Spring of 1919 and Fall of 1919 | 50 | .506±.071 |
| Spring of 1920 | 54 | .665±.051 |
| Fall of 1920 | 51 | .505±.070 |
| Spring of 1921 | 48 | .517±.071 |

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings—(Continued)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| **Fall of 1921** | 46 | .327±.089 |
| Spring of 1922 | 45 | .537±.072 |
| Fall of 1922 | 47 | .506±.073 |
| Spring of 1923 | 36 | .506±.084 |
| Fall of 1919 and Spring of 1920 | 49 | .389±.082 |
| Fall of 1920 | 47 | .560±.068 |
| Spring of 1921 | 44 | .482±.078 |
| Fall of 1921 | 42 | .409±.087 |
| Spring of 1922 | 41 | .455±.084 |
| Fall of 1922 | 43 | .580±.068 |
| Spring of 1923 | 34 | .506±.086 |
| Spring of 1920 and Fall of 1920 | 50 | .533±.068 |
| Spring of 1921 | 47 | .478±.076 |
| Fall of 1921 | 45 | .434±.082 |
| Spring of 1922 | 44 | .578±.068 |
| Fall of 1922 | 46 | .540±.070 |
| Spring of 1923 | 36 | .412±.093 |
| Fall of 1920 and Spring of 1921 | 58 | .558±.061 |
| Fall of 1921 | 54 | .511±.068 |
| Spring of 1922 | 54 | .418±.076 |
| Fall of 1922 | 53 | .714±.045 |
| Spring of 1923 | 41 | .484±.081 |
| Spring of 1921 and Fall of 1921 | 54 | .563±.063 |
| Spring of 1922 | 54 | .543±.065 |
| Fall of 1922 | 53 | .401±.078 |
| Spring of 1923 | 41 | .660±.060 |
| Fall of 1921 and Spring of 1922 | 53 | .226±.088 |
| Fall of 1922 | 52 | .377±.080 |
| Spring of 1923 | 40 | .510±.079 |
| Spring of 1922 and Fall of 1922 | 51 | .478±.073 |
| Spring of 1923 | 39 | .534±.077 |
| Fall of 1922 and Spring of 1923 | 41 | .618±.065 |
| Average of 66 correlations for the foundation registered does | | .429±.011 |
| Registered does 50-93, born at the Station in the Spring of 1919 (Includes a total of 28 different individuals) | | |
| Fall of 1919 and Spring of 1920 | 20 | .490±.115 |
| Fall of 1920 | 20 | .460±.119 |
| Spring of 1921 | 20 | .320±.135 |
| Fall of 1921 | 19 | .534±.111 |
| Spring of 1922 | 22 | .245±.135 |
| Fall of 1922 | 20 | .061±.150 |
| Spring of 1923 | 19 | .371±.133 |
| Spring of 1920 and Fall of 1920 | 18 | .779±.063 |
| Spring of 1921 | 20 | .663±.085 |
| Fall of 1921 | 19 | .291±.142 |
| Spring of 1922 | 21 | .382±.126 |
| Fall of 1922 | 19 | .376±.133 |
| Spring of 1923 | 18 | .502±.119 |
| Fall of 1920 and Spring of 1921 | 21 | .707±.074 |
| Fall of 1921 | 20 | .738±.069 |
| Spring of 1922 | 22 | .621±.089 |
| Fall of 1922 | 20 | .764±.063 |
| Spring of 1923 | 19 | .695±.080 |
| Spring of 1921 and Fall of 1921 | 23 | .529±.101 |
| Spring of 1922 | 24 | .700±.070 |
| Fall of 1922 | 22 | .460±.113 |
| Spring of 1923 | 21 | .591±.096 |
| Fall of 1921 and Spring of 1922 | 24 | .530±.099 |
| Fall of 1922 | 22 | .483±.110 |
| Spring of 1923 | 21 | .664±.082 |
| Spring of 1922 and Fall of 1922 | 25 | .606±.085 |

Table 1. Correlations between the Weights of Fleeces Produced by Angora Goats at Different Shearings—(Continued)

| | No. of Goats Included | Coefficient of Correlation |
|---|---|---|
| Spring of 1923 | 24 | .631±.083 |
| Fall of 1922 and Spring of 1923 | 24 | .648±.080 |
| Average of 28 correlations for the registered does born in 1919 | | .530±.022 |
| **Registered does 103-150, born at the station in the Spring of 1920.** | | |
| (Includes a total of 15 individuals) | | |
| Spring of 1921 and Fall of 1921 | 11 | .662±.114 |
| Spring of 1922 | 10 | .318±.192 |
| Fall of 1922 | 10 | .026±.213 |
| Fall of 1921 and Spring of 1922 | 11 | .289±.186 |
| Fall of 1922 | 11 | .415±.169 |
| Spring of 1923 | 10 | .573±.143 |
| Spring of 1922 and Fall of 1922 | 14 | .775±.072 |
| Spring of 1923 | 13 | .736±.086 |
| Fall of 1922 and Spring of 1923 | 13 | .796±.069 |
| Average of 9 correlations for the registered does born in 1920 | | .510±.056 |
| **Registered does 154-225, born at the Station in the Spring of 1921.** | | |
| (Includes a total of 30 individuals) | | |
| Fall of 1921 and Spring of 1922 | 30 | .305±.112 |
| Fall of 1922 | 27 | .425±.106 |
| Spring of 1923 | 26 | .515±.097 |
| Spring of 1922 and Fall of 1922 | 27 | .614±.080 |
| Spring of 1923 | 26 | .592±.086 |
| Fall of 1922 and Spring of 1923 | 24 | .802±.049 |
| Average of 6 correlations for the registered does born in 1920 | | .542±.043 |
| **Registered Does 227-282, born at the Station in the Spring of 1922.** | | |
| Fall of 1922 and Spring of 1923 | 16 | .349±.148 |
| Average of the 110 correlations on five groups of registered does including 155 different individuals | | .467±.011 |

Summary of Table 1

| | Number of Correlations | Number of Different Goats Involved | Average Coefficient of Correlation | Percentage of Individual Differences Which Are Permanent |
|---|---|---|---|---|
| Grade Does | 162 | 631 | .392±.011 | 15.4% |
| Grade Wethers | 24 | 313 | .369±.028 | 13.6% |
| Registered Bucks | 6 | 67 | .255±.068 | 6.5% |
| Registered Does | 110 | 155 | .467±.011 | 21.8% |
| All Goats | 302 | 1166 | .415±.008 | 17.2% |

## VARIATIONS IN INDIVIDUALITY IN DIFFERENT GROUPS

The differences between the average coefficients of correlation for the different groups of goats shown in the summary of Table 1 are as follows:

| | Difference | Difference Divided by Probable Error |
|---|---|---|
| Grade Does and Grade Wethers | .023±.030 | .8 |
| Grade Does and Registered Bucks | .137±.087 | 1.6 |
| Grade Does and Registered Does | .075±.016 | 4.7 |
| Grade Wethers and Registered Bucks | .114±.090 | 1.3 |
| Grade Wethers and Registered Does | .098±.030 | 3.3 |
| Registered Bucks and Registered Does | .212±.087 | 2.4 |

The only statistically significant difference is that between the average correlation for the grade does and the average correlation for the registered does, which (although small) is 4.7 times as large as its probable error. The difference between the average correlation for the grade wethers and the average correlation for the registered does is on the border line of significance, being 3.3 times as large as its probable error. The possibility that both of these differences should be as large as they are and both in the same direction just as a matter of chance is so remote that we can safely conclude that there is a real reason why the registered does showed a higher correlation than the grade does and grade wethers. Various conjectures can be made as to what that reason is, but the one which fits the facts best and seems truest to the authors is that there was more genetic variability among the registered does which were obtained from several different sources and which were, for experimental reasons, mated to various types of bucks, than among the grade does of which the foundation stock all came from two flocks (most of it from one) and which were bred to registered bucks of a rather uniform general type for the production of the grade goats born at the station.

Too much importance should not be attached to the differences between the average coefficients of correlation shown in the summary of Table I because the groups averaged together in that summary were composed of smaller groups which did not all show the same amount of correlation. For example, the average coefficients of correlation* for the first six groups of grade does (which are included in one group in the summary of Table I) are as follows:

| | | |
|---|---|---|
| Does | 1- 51 | .311±.036 |
| " | 52-154 | .544±.019 |
| " | 155-291 | .249±.034 |
| " | 292-416 | .424±.017 |
| " | 418-684 | .405±.016 |
| " | 687-941 | .542±.007 |

*Copied from Table 1.

The differences between the average coefficients of correlation for these different groups of grade does are as follows:

| | | | | Difference | Difference Divided by Probable Error |
|---|---|---|---|---|---|
| Does | 1- 51 | and | does 52-154 | .233±.041 | 5.7 |
| " | " " | | does 155-291 | .062±.050 | 1.2 |
| " | " " | | does 292-416 | .113±.040 | 2.8 |
| " | " " | | does 418-684 | .094±.039 | 2.4 |
| " | " " | | does 687-941 | .231±.037 | 6.2 |
| Does | 52-154 | and | does 155-291 | .305±.039 | 7.8 |
| " | " " | | does 292-416 | .120±.025 | 4.8 |
| " | " " | | does 418-684 | .139±.025 | 5.6 |
| " | " " | | does 687-941 | .002±.020 | .1 |
| Does | 155-291 | and | does 292-416 | .175±.038 | 4.6 |
| " | " " | | does 418-684 | .156±.038 | 4.1 |
| " | " " | | does 687-941 | .293±.035 | 8.4 |
| Does | 292-416 | and | does 418-684 | .019±.023 | .8 |
| " | " " | | does 687-941 | .118±.018 | 6.6 |
| Does | 418-684 | and | does 687-941 | .137±.017 | 8.1 |

It will be seen that each of these six groups of does shows an average coefficient of correlation significantly different from that of several of the other five groups. Some of the reasons for these differences are definitely known. Thus the low average correlation of does 1-51 is largely due to the fact that they were carefully selected when they were purchased and therefore did not show the full range of variation which the entire flock from which they were chosen would have shown. Does 52-154 and does 292-416 were also purchased but were not selected one by one after a careful examination as does 1-51 were. Therefore, does 52-154 and does 292-416 may naturally have been expected to show more variation in permanent differences and higher correlations than does 1-51. No satisfactory explanation of the low average correlation for does 155-291 is apparent. Neither is there any apparent explanation of the remarkable uniformity shown by does 687-941 in the size of the various coefficients of correlation which go to make up their average coefficient of correlation. It is this uniformity which is responsible for the extreme smallness of the probable error for the average coefficient of correlation for this group.

Thus it is clear that there are real differences between different groups of goats in regard to the amount of correlation which they show, although the reasons for those differences are not completely known. It is important to know the amount of correlation which any group of goats would show between fleece weights at different shearings because the success of culling depends on that. It is evident that the Experiment Station would have gained much more by culling does 52-154 or does 687-941 than it would by culling does 1-51 or 155-291. Further references to these differences between groups will be made later in the discussion of individuality and heredity.

## STATISTICAL SIGNIFICANCE OF THE CORRELATIONS

It will be noticed that a few of the correlations in Table 1 are negative and that nearly a third of them are not large enough to be statis-

tically significant; that is, are less than three times their probable errors. None of the negative correlations are statistically significant, and the great majority of all correlations are positive, nearly half of them being more than five times as large as their probable errors. Hence it cannot be doubted that on the average there is a significant positive correlation between the weights of individual fleeces of Angora goats at different shearings, but this correlation is not as large as the similar correlation for Rambouillet sheep. The correlations are summed up as to their significance in Table 2.

Table 2. Statistical Significance of the Correlations

| | Negative | Positive |
|---|---|---|
| Less than their probable errors | 9 | 19 |
| From one to three times as large as their probable errors | 5 | 56 |
| From three to five times as large as their probable errors | 0 | 66 |
| More than five times as large as their probable errors | 0 | 148 |
| Total | 14 | 288 |

Largest negative correlation (21 individuals) is $-.346 \pm .130$
Largest positive correlation (34 individuals) is $+.861 \pm .030$

## THE INFLUENCE OF THE NUMBER OF INDIVIDUALS INVOLVED UPON THE SIZE OF THE CORRELATION

Some of the correlations are based upon very small numbers of individuals and it might be supposed that it is these correlations which have the unusually high and the unusually low coefficients or it might be sup-

Number of Goats in Each Correlation Table

| Size of the Coefficient of Correlation | 8-12 | 13-17 | 18-22 | 23-27 | 28-32 | 33-37 | 38-42 | 43-47 | 48-52 | 53-57 | 58-62 | 63-67 | 68-72 | 73-77 | 78-82 | 83-87 | 88-92 | 93-97 | 98-102 | 103-107 | 108-112 | 113-117 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -.39 to -.30 | | 1 | 1 | | | | | | | | | | | | | | | | | | | | 2 |
| -.29 to -.20 | | | | | 1 | | | | | | | | | | | | | | | | | | 1 |
| -.19 to -.10 | | | 2 | 1 | 1 | | | | | | | | | | | | | | | | | | 4 |
| -.09 to -.00 | 1 | 1 | 2 | | | 2 | 1 | | | | | | | | | | | | | | | | 7 |
| +.00 to +.09 | 3 | | 2 | 3 | 1 | 2 | | 1 | 1 | 1 | | | | | | | | | | | | | 14 |
| +.10 to +.19 | 2 | 1 | 3 | | 1 | 3 | | | | | 1 | | | | | | | 1 | | | | | 12 |
| +.20 to +.29 | 1 | 3 | 4 | | 1 | 6 | 4 | 3 | 2 | 1 | | 2 | | 2 | 1 | | | | 1 | | | | 31 |
| +.30 to +.39 | 4 | 3 | 10 | 1 | 2 | 6 | | 7 | 9 | | | | 2 | | 1 | | | 1 | | 1 | | 1 | 48 |
| +.40 to +.49 | 6 | 1 | 7 | 5 | 1 | 7 | 7 | 6 | 4 | 3 | | 2 | 1 | 3 | | 2 | | 3 | | 1 | 2 | 2 | 63 |
| +.50 to +.59 | 8 | 3 | 4 | 5 | 1 | 10 | 5 | 11 | 4 | 4 | 2 | 3 | 2 | 1 | 3 | 1 | | 2 | | 2 | 3 | | 74 |
| +.60 to +.69 | 3 | 1 | 5 | 7 | 1 | 6 | 2 | | 2 | 1 | 1 | | | | | | | 1 | | | 1 | | 31 |
| +.70 to +.79 | 1 | 3 | 5 | 2 | | | | | | 1 | | | | | | | | | | | | | 12 |
| +.80 to +.89 | | | | 1 | 1 | 1 | | | | | | | | | | | | | | | | | 3 |
| | 29 | 17 | 45 | 25 | 11 | 43 | 19 | 28 | 22 | 11 | 4 | 7 | 5 | 6 | 5 | 3 | | 8 | 1 | 4 | 6 | 3 | 302 |

Coefficient of Correlation = $+.097 \pm .038$

Figure 4. The Relation between the size of the coefficient of correlation and the number of individuals upon which that correlation is based.

posed that these correlations based upon very small numbers unduly influence the average value of all correlations.

The relation between the number of individuals involved and the size

of the coefficient of correlation is shown in Figure 4, which is itself in the form of a correlation table. The use of the correlation coefficient is not justified in this case because neither distribution is in agreement with the normal frequency curve and regression is clearly non-linear. The correlation ratios (which are used instead of the coefficient of correlation in the cases of non-linear regression) are .217 and .306 for the data in Figure 4. They show that the extreme coefficients do come from the correlations involving smaller numbers of individuals and that there is a slight tendency for the correlations involving larger numbers to have larger coefficients. This table makes it seem still more probable that coefficients less than +.20 or more than +.69 are so abnormal in size merely because they are based upon insufficient numbers.

## INDIVIDUALITY IN FALL SHEARINGS COMPARED WITH INDIVIDUALITY IN SPRING SHEARINGS

While working over the shearing records the authors were impressed, merely by inspection, with the fact that there were many goats, particularly among the wethers, which consistently produced fleeces in the fall very much heavier than the average of their group but produced fleeces of ordinary or inferior weight in the spring. There were others which did exactly the opposite; that is, produced heavy fleeces in the spring and light ones in the fall, but these were not so conspicuous. Table 3 shows that this general impression gained from glancing at the individual fleece weight records was founded on actual fact. Table 3 shows that fall shearings are correlated with other fall shearings and spring shearings are correlated with other spring shearings more closely than fall shearings are correlated with spring shearings. This is all the more surprising because consecutive shearings might have been expected to have been more closely correlated than shearings which were separated by at least one other shearing. This was actually found to be true in the case of the sheep studied in Texas Bulletin 311, and is to be expected for the reason that there will be temporary environmental influences, such as a minor illness or parasitism, which will affect individual goats over a large part of two consecutive fleece-growing periods but will not last all through the life-times of those goats. However, in Table 3 all the correlations of consecutive shearings (except one involving registered bucks and one involving the foundation registered does) are correlations of fall shearings with spring shearings, and therefore we would have expected the average of the "fall with spring" correlations to be higher than the others, whereas it is actually lower and the difference is statistically significant.

A detailed examination of Table 3 will show that this difference is due entirely to the grade wethers and grade does, and shows up in every complete comparison of those groups except that the difference is small in the case of grade does Nos. 687-941.

Expressed in the language of the practical breeder, all of this merely means that in the groups of grade goats there were many individuals which usually produced heavy fleeces in the fall and fleeces of ordinary

weight in the spring and many other individuals which usually produced heavy fleeces in the spring and fleeces of ordinary weight in the fall. At present we can do no more than speculate as to the reasons for this habit. It is quite possible that it is related to the variations in the shrinkage of individual fleeces. The fall fleeces (where this difference showed up most pronounced) were grown during the long hot summers and it may be that certain individuals responded to this hot weather by producing much more sweat and yolk in their fleeces than others. Or the difference may have been due to individual feeding habits and peculiarities of taste since the food eaten during the spring and summer naturally differed from that eaten during the fall and winter.

The fact that the difference was present in the grades but not in the purebreds is some indication that it rests upon a hereditary basis and that by careful selection and breeding it might be possible to establish strains of Angora goats in which this difference would be even more pronounced than it was in the grade Angora goats on which this study was based. There does not appear to be any economic reason for attempting to establish such a strain of goats, however, and since the available data are not enough to show conclusively which explanation is correct we shall have to be content with merely stating the observed fact that fall fleeces from the same goats tend to resemble each other in weight, and spring fleeces from the same goats tend to resemble each other in weight, more closely than fall fleeces and spring fleeces from the same goats tend to resemble each other in weight. Since this is true and the fall fleece is heavier than the spring fleece (as will be shown later), it would seem that the fall shearing is a better time to cull goats for increased mohair-production than the spring shearing.

Table 3. Correlations of Fall Shearings Compared With Correlations of Spring Shearings

| Goats included | Shearings Correlated | | |
|---|---|---|---|
| | Fall with Fall | Fall with Spring | Spring with Spring |
| Average of all | .440±.018 | .377±.010 | .492±.016 |
| Grade does 1-51 | .233 | .238 | .583 |
| Grade does 52-154 | .593 | .470 | .717 |
| Grade does 155-291 | .288 | .168 | .424 |
| Grade does 292-416 | .466 | .399 | .443 |
| Grade does 418-684 | .487 | .327 | .530 |
| Grade does 687-941 | .548 | .527 | .582 |
| Grade does 943-1141 | | .455 | |
| Grade does 1142-1178 | | .240 | |
| Grade wethers 157-290 | .534 | .209 | .468 |
| Grade wethers 417-686 | .585 | .404 | .593 |
| Grade wethers 688-942 | | .545 | |
| Grade wethers 944-1139 | | .281 | |
| Grade wethers 1145-1179 | | .343 | |
| Registered bucks | | .233 | .365 |
| Foundation registered does | .445 | .428 | .424 |
| Registered does 50-93 | .507 | .521 | .578 |
| Registered does 103-150 | .415 | .520 | .527 |
| Registered does 154-225 | .425 | .559 | .592 |
| Registered does 227-282 | | .349 | |
| Number of tables involved | 56 | 177 | 69 |

## THE INFLUENCE OF THE LENGTH OF TIME BETWEEN SHEARINGS UPON THE SIZE OF THE CORRELATION

It was shown in Texas Bulletin No. 311 that the correlation between the individual fleece weights of sheep was significantly higher in the case of consecutive shearings than in the case of shearings which were not consecutive and that there seemed to be a tendency for the correlations to be still lower as the interval of time between the shearings was increased. It is very easy to understand why this should be so, because there are many cases of minor illness or of parasitism which extend over more than one fleece-growing period and which may therefore affect the weight of two consecutive fleeces but may not affect the weight of a fleece produced three or four years later. Also it is possible that some individuals become broken-mouthed and show the effects of old age before others. This would tend to make the correlations lower between fleeces produced when the animals were old and fleeces produced when they were young than similar correlations between fleeces both of which were produced when the animals were young or both of which were produced when the animals were old. It was to show whether this same state of affairs existed among Angora goats that Table 4 was prepared.

At first glance Table 4 does not seem to conform to expectation at all since the correlations for consecutive shearings are significantly lower than for shearings separated by one other shearing and shearings separated by three other shearings. However, if Table 4 is considered in connection with Table 3 it becomes evident that the situation in Angora goats is really very similar to what it is in sheep. In the case of the Angora goats all of the correlations between consecutive shearings are correlations between fall shearings and spring shearings (except for two exceptional cases among the registered goats), while correlations between shearings separated by one other shearing are all (with one exception) correlations between two fall shearings or between two spring shearings. To eliminate this influence of the lower correlations between spring and fall shearings, only shearings separated by an even number of shearings ought to be compared with each other and shearings separated by an odd number of shearings ought to be compared with each other. Thus correlations of consecutive shearings ought to be compared with correlations of shearings separated by two, four, six, eight, or ten, other shearings. Likewise correlations of shearings separated by one other shearing ought to be compared with correlations of shearings separated by three, five, seven, or nine other shearings. When this is done it will be seen that there is a gradual decline in the value of the correlation as the length of time between the two shearings increases. Table 4 furnishes strong confirmation of the fact shown in Table 3, namely, that fall fleece weights resemble other fall fleece weights and spring fleece weights resemble other spring fleece weights more closely than fall fleece weights resemble spring fleece weights.

Table 4. The Influence of the Length of Time Between Shearings Upon the Size of the Correlation

| Goats Involved | Consecutive Shearings | Shearings separated by one other shearing | Shearings separated by two other shearings | Shearings separated by three other shearings | Shearings separated by four other shearings | Shearings separated by five other shearings | Shearings separated by six other shearings | Shearings separated by seven other shearings | Shearings separated by eight other shearings | Shearings separated by nine other shearings | Shearings separated by ten other shearings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Average of all | .410 ± .015 | .511 ± .015 | .375 ± .017 | .497 ± .020 | .314 ± .028 | .373 ± .032 | .273 ± .053 | .294 ± .058 | .298 ± .031 | .341 | .190 |
| Grade does 1—51 | .381 | .486 | .275 | .395 | —.027 | .201 | —.148 | .... | .... | .... | .... |
| Grade does 52—154 | .448 | .656 | .499 | .653 | .495 | .... | .... | .... | .... | .... | .... |
| Grade does 155—291 | .157 | .366 | .227 | .373 | .225 | .294 | —.214 | .... | .... | .... | .... |
| Grade does 292—416 | .398 | .506 | .435 | .513 | .420 | .473 | .313 | .037 | .322 | .... | .... |
| Grade does 418—684 | .358 | .553 | .325 | .522 | .280 | .345 | .262 | .... | .... | .... | .... |
| Grade does 687—941 | .516 | .562 | .537 | .571 | .550 | .... | .... | .... | .... | .... | .... |
| Grade does 943—1141 | .... | .420 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade does 1142—1178 | .240 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 157—290 | .274 | .554 | .198 | .396 | —.084 | .... | .... | .... | .... | .... | .... |
| Grade wethers 417—686 | .490 | .589 | .143 | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 688—942 | .545 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 944—1139 | .281 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 1145—1179 | .343 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Registered bucks | .271 | .176 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Foundation registered does | .439 | .470 | .433 | .518 | .382 | .430 | .413 | .423 | .290 | .341 | .190 |
| Registered does 50—93 | .613 | .613 | .471 | .568 | .439 | .282 | .371 | .... | .... | .... | .... |
| Registered does 103—150 | .531 | .490 | .300 | .... | .... | .... | .... | .... | .... | .... | .... |
| Registered does 154—225 | .574 | .509 | .515 | .... | .... | .... | .... | .... | .... | .... | .... |
| Registered does 227—282 | .349 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Number of correlation tables included | 83 | 63 | 49 | 36 | 27 | 18 | 12 | 6 | 4 | 2 | 1 |

## THE INFLUENCE OF AGE UPON INDIVIDUALITY

For economic reasons it is best to cull a flock when the animals are as young as possible, provided it is possible to do the culling as *accurately* at that age as at any other age. Hence it becomes important to know whether the differences in individuality are fully developed by the time the goats are sheared as kids, or whether it will be necessary to wait until they are yearlings, two-year-olds, or even older before they can be culled on the basis of fleece weights with the greatest accuracy. Table 5 was prepared to show the evidence on this point. In it the correlations are sorted out according to the age of the goats involved and all those involving the same age are averaged together. Since each correlation concerns two different ages of the same goats, each correlation is counted twice, and only twice, in this table. Two groups of does are omitted from this table because they were not absolutely uniform in age and two others are shown but not included in the averages because they were not born at the Station and therefore may not have been subject to similar environmental influences while young.

It is evident from Table 5 that, with two exceptions, the correlations at different ages are very nearly the same. The fleece weights when the goats were kids (that is, were about six months old) seem to be less reliable than the other fleece weights and the fleece weights in the fall of the yearling year (that is, when the goats were about eighteen months old) seem to be more reliable than other fleece weights as indicators of the future weight of fleece which the goats will produce.

The difference between the correlation for the kid shearing and the next lowest correlation is only one and one-half times its probable error but the differences between the correlation for the kid shearing and most of the other correlations are more than three times as large as their probable errors and therefore we can be reasonably sure that the kid fleece is not as accurate an indicator of the future mohair-producing ability of the goat as the later fleeces are and, other things being equal, it would be best to postpone culling until a later shearing time. The kid fleece is not as accurate an indicator as the others because of two reasons. In the first place all the kids are not born on the same day or even in the same week and therefore they come to their first shearing carrying fleeces which have not all had the same length of time in which to grow. In the second place, there is probably more variation in the amount of milk which they get from their mothers than there is in the amount of feed which they collect for themselves at later periods in their lives. That is, the food supply for the individual kids is probably less uniform than it is for older goats.

The difference between the correlation for the fall yearling shearing and the next highest correlation is only about twice as large as its probable error but most of the differences between the fall yearling correlation and the other correlations are nearly or quite three times as large as their probable errors and therefore we can be reasonably sure that, as a rule, the fall yearling fleece weights are more reliable than the fleece weights at

any other age as indicators of the amounts of mohair which the goats are apt to produce in the future. It is perhaps significant that this most reliable age is also the age at which the heaviest fleece is produced (as will be shown later). It would seem that differences in individuality show up best when production is best and that the conditions which tend to make the average production low, hurt the good-producers proportionately more than they do the poor-producers. In other words, unfavorable conditions tend to hold all the goats down to a dead level of low production. There was some indication of this also in the case of sheep as reported in Texas Bulletin 311. However, in neither case is the evidence perfectly clear-cut and free from contradictions.

On the basis of the facts just shown, it is obvious that the best time to cull Angora goats for increased mohair production is at the fall shearing of their yearling year. If, for reasons of prices or ranch management, it is not expedient to do the culling at this age, any other age will do about as well except that they should not be culled in the fall as kids if the culling can possibly be done at any other age.

Table 5 The Influence of Age Upon the Amount of Correlation

| Goats included | AGE IN YEARS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 5½ | 6 |
| Average for all goats born at the Station | .306 ± .021 | .428 ± .018 | .506 ± .019 | .394 ± .025 | .424 ± .024 | .442 ± .027 | .360 ± .032 | .436 ± .035 | | | | |
| Grade does 155—291 | .032 | .432 | .337 | .024 | .287 | .332 | .223 | .324 | .... | .... | .... | .... |
| Grade does 418—684 | .352 | .446 | .455 | .426 | .404 | .385 | .371 | .398 | .... | .... | .... | .. |
| Grade does 687—941 | .533 | .542 | .552 | .521 | .520 | .584 | .... | .... | .... | .... | .... | .. . |
| Grade does 943—1141 | .455 | .420 | .... | .420 | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade does 1142—1178 | .240 | .240 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 157—290 | .236 | .397 | .455 | .287 | .326 | .254 | .... | .... | .... | .... | .... | .... |
| Grade wethers 417—686 | .388 | .535 | .540 | .398 | .... | .... | .... | .... | .... | .... | .... | .. . |
| Grade wethers 688—942 | .545 | .545 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 944—1139 | .281 | .281 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade wethers 1145—1179 | .343 | .343 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Registered bucks | .152 | .199 | .... | .271 | .... | .... | .... | .... | .... | .... | .... | .... |
| Registered does 50—93 | .354 | .498 | .681 | .567 | .538 | .531 | .485 | .586 | .... | .... | .... | .... |
| Registered does 103—150 | .... | .335 | .485 | .530 | .503 | .702 | .... | .... | .... | .... | .. . | .... |
| Registered does 154—225 | .415 | .504 | .614 | .636 | .... | .... | .... | .... | .... | .... | .... | .... |
| Registered does 227—282 | .349 | .349 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Grade does 1—51 (not included in average) | .... | .... | .... | .... | .311 | .350 | .184 | .550 | .263 | .476 | .187 | .169 |
| Grade does 292—416 (not included in average) | ... | .. . | .372 | .351 | .472 | .447 | .483 | .497 | .393 | .300 | .424 | .498 |

## THE INFLUENCE OF SEASON UPON INDIVIDUALITY

It is perfectly possible that seasonal influences such as the scarcity or abundance of feed, the temperature and humidity of the air, etc., might influence the grease weights of the fleeces so much that the fleece weights of some particular season would be very much more reliable indicators of the future mohair-producing ability of the goats than the fleece weights of other seasons. Table 6 was prepared to show whether this was actually true. Since each correlation table necessarily involves shearings at two different seasons, each correlation is counted twice and only twice in this table. The four groups of purchased does are given but are not included in the averages because of the possibility of their having been reared under quite different environmental conditions. Only two of the averages given in that table differ significantly from the general average of all correlations. One of these is the average for the fall of 1918, which was very significantly lower than the general average, but which rested solely upon the kid shearings of the does and wethers which were born in 1918, during which year there was a severe drouth. The correlations for the purchased does are also slightly lower in the fall of 1918 than their general average but the difference is not nearly as extreme as it is in the case of the two groups which were included in the average. The average correlation for the spring shearing of 1923 is distinctly higher than the average of all correlations and this is found so generally among the different groups that it seems unlikely that it is entirely accidental. The spring shearing of 1923 was heavier than the average spring shearing (as will be shown later) and followed six months of weather and pasture conditions almost ideal for goats. Since pasture conditions preceding the 1923 spring shearing were better than the average and pasture conditions preceding the 1918 fall shearing were more unfavorable than the average, this may be regarded as some further evidence that good conditions and heavy fleeces are accompanied by high correlations. However, the evidence does not agree completely with this hypothesis, for the 1921 fall shearing and the 1922 spring shearing, both of which were small and both of which followed periods of scanty pasture, nevertheless had average correlations which were higher than the average of all correlations.

For the present we can only draw the tentative conculsion that seasonal variations have little or no influence upon the size of the correlation. One season is as good as another for culling goats for increased mohair-production. There is some evidence that the correlation is highest when it concerns seasons when the fleece weights are heaviest but this evidence is not absolutely conclusive. We have not found a perfect explanation for the very low correlations involving the 1918 fall shearing and for the high correlations involving the 1923 spring shearing .

Table 6 The Influence of Season Upon the Amount of Correlation

| Goats included | Long Spring 1917 | Long Spring 1918 | Fall 1918 | Spring 1919 | Fall 1919 | Spring 1920 | Fall 1920 | Spring 1921 | Fall 1921 | Spring 1922 | Fall 1922 | Spring 1923 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average for all goats born at the Station | .... | .... | .117 ± .043 | .417 ± .029 | .377 ± .022 | .338 ± .030 | .440 ± .027 | .401 ± .027 | .430 ± .020 | .441 ± .023 | .451 ± .025 | .513 ± .021 | .415 ± .008 |
| Grade does 155—291 | .... | .... | .032 | .432 | .337 | .024 | .287 | .332 | .223 | .324 | .... | .... | .249 ± .034 |
| Grade does 418—684 | .... | .... | .... | .. . | .352 | .446 | .455 | .426 | .404 | .385 | .371 | .398 | .405 ± .016 |
| Grade does 687—941 | .... | .... | .... | .. . | .... | .... | .533 | .542 | .552 | .521 | .520 | .584 | .542 ± .007 |
| Grade does 943—1141 | .... | .... | .... | .... | .... | .... | .... | .... | .455 | .420 | .... | .489 | .455 |
| Grade does 1142—1178 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .240 | .240 | .240 ± .146 |
| Grade wethers 157—290 | .... | .... | .236 | .397 | .455 | .287 | .326 | .254 | .... | .... | .... | .. . | .326 ± .038 |
| Grade wethers 417—686 | .... | .... | .... | .... | .388 | .535 | .540 | .398 | .... | .... | .... | .... | .465 ± .043 |
| Grade wethers 688—942 | .... | .... | .... | .... | .... | ... | .545 | .545 | .... | .... | .... | .... | .545 ± .057 |
| Grade wethers 944—1139 | .... | .... | .... | .... | .... | .... | .... | .... | .281 | .281 | .... | .... | .281 ± .077 |
| Grade wethers 1145–1179 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .343 | .343 | .343 ± .180 |
| Registered bucks | .... | .... | .... | .... | .558 | .... | —.077 | .018 | .610 | .384 | .150 | .150 | .255 ± .086 |
| Registered does 50—93 | .... | .... | .... | .... | .354 | .498 | .681 | .567 | .538 | .531 | .485 | .586 | .530 ± .022 |
| Registered does 103—150 | .... | .... | .... | .... | .... | .... | .... | .335 | .485 | .530 | .503 | .702 | .510 ± .056 |
| Registered does 154—225 | .... | .... | .... | .... | .... | .... | .... | .... | .415 | .504 | .614 | .636 | .542 ± .043 |
| Registered does 227—282 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .349 | .349 | .349 ± .148 |
| Foundation registered does (not included in average) | .275 | .392 | .344 | .491 | .458 | .464 | .481 | .431 | .411 | .470 | .476 | .456 | .429 ± .011 |
| Grade does 1—51 (not included in average) | .... | .... | .311 | .350 | .184 | .550 | .263 | .476 | .187 | .169 | .... | .... | .311 ± .036 |
| Grade does 52—154 (not in average) | .... | .... | .539 | .585 | .523 | .561 | .495 | .561 | .... | .... | .... | .... | .544 ± .019 |
| Grade does 292—416 (not in average) | .... | .... | .372 | .351 | .472 | .447 | .483 | .497 | .393 | .300 | .424 | .498 | .424 ± .017 |

## INDIVIDUALITY AND HEREDITY

Individuality is defined in this Bulletin as the permanent differences between individuals of the same age and sex and of similar breeding. In other words individuality is the sum of the characteristics (aside from sex, age, and general type of breeding) which permanently distinguish one individual from another. The differences which are included under the term, individuality, can be separated for purposes of analysis into two classes; those which are due to differences in heredity and those which are due to non-hereditary causes. In actual practice it is usually impossible to lay one's hand on two goats, for instance, and say that one particular difference between them is due to differences in heredity and that some other particular difference between them is not due to heredity.

However, for practical purposes, it is of tremendous importance to know whether a permanent difference in some desirable characteristic is the result of hereditary difference or of environmental forces. This is true, because, so far as is known at present, the effects of environmental forces are rarely or never inherited to any extent whatever. Therefore, if the permanent differences in fleece-weight are caused entirely by environmental forces, culling will improve the average of the flock upon which culling is practiced but will not improve the average of the offspring of that flock. That is, the effects of selection will be confined to the animals actually selected and it will be necessary to begin the improvement over again with each generation. On the other hand, if the differences are due to heredity, improvement will be made in the flock from which the culls were removed and the offspring of the selected animals will retain some of that improvement and will be superior to the offspring of the rejected animals.

Applying this general principle to the character studied in this Bulletin, fleece-weight of Angora goats, we have the following situation: Within groups of the same age, sex, and general breeding, about fifteen to twenty per cent of the differences in fleece-weight have been found to be permanent.* The efficiency of selection in the generation which is selected is not affected at all by whether those permanent differences are hereditary or non-hereditary. However, the extent to which the kids of the selected does will have heavier fleeces than the kids of the rejected does will depend upon the extent to which the permanent differences between the selected and rejected does are caused by heredity.

Our present data are not enough to enable us to say positively what proportion of these permanent differences are hereditary but there are several indications that it is large. In the summary of Table 1 it will be noticed that the correlations for the registered does which were purchased from various breeders and were of diverse lines of breeding were larger than for the grade does and wethers, of which each group was bred by one breeder and therefore may naturally have been expected to have been

*The square of the coefficient of correlation gives the degree of determination, and the square of the average coefficient of correlation in this case (+.415) equals .172 or in other words, 17.2% of the differences in fleece weights were permanent.

more uniform in heredity than the registered does. The low correlations of the registered bucks are probably due to the fact that nearly all of these correlations concern kid shearings. Also the registered bucks had been rigidly culled to a certain standard of fleece whereas the other groups had not been so rigidly culled at the time when most of the shearings were made.

There were hereditary differences between different groups of does (see Table 1 and the discussion immediately following) which would have caused the correlations to have been higher if the does had not been so rigidly separated into groups of the same general breeding. Grade does 1-154 furnish an excellent illustration of this. Grade does 1-51 were choice does purchased from one breeder's flock and grade does 52-154 were average does purchased from another breeder's flock. The former were distinctly superior to the latter in the amount of mohair which they produced (as is shown in Table 9) and presumably their superiority was due largely to their better breeding although, of course, some of it may have been the result of a better environment while they were young. The coefficients of correlation were calculated for the entire group of does 1-154 and are presented in Table 7 side by side with the correlations of the two separate groups of does, repeated from Table 1.

Table 7. Correlations Involving Grade Does 1-51 and Grade Does 52-154 in Separate Groups and correlations Involving All Grade Does 1-154 in One Group

| Shearings involved | Grade Does 1-51 | Grade Does 52-154 | Grade Does 1-154 |
|---|---|---|---|
| Fall of 1918 and Spring of 1919 | .467 | .469 | .478 |
| Fall of 1919 | .494 | .568 | .533 |
| Spring of 1920 | .509 | .545 | .501 |
| Fall of 1920 | .530 | .620 | .558 |
| Spring of 1921 | .239 | .495 | .375 |
| Spring of 1919 and Fall of 1919 | .267 | .526 | .652 |
| Spring of 1920 | .638 | .739 | .779 |
| Fall of 1920 | .273 | .504 | .480 |
| Spring of 1921 | .458 | .686 | .733 |
| Fall of 1919 and Spring of 1920 | .300 | .485 | .577 |
| Fall of 1920 | .429 | .590 | .615 |
| Spring of 1921 | .203 | .448 | .591 |
| Spring of 1920 and Fall of 1920 | .439 | .312 | .499 |
| Spring of 1921 | .804 | .725 | .840 |
| Fall of 1920 and Spring of 1921 | .364 | .449 | .574 |
| Average coefficient of correlation | +.428±.027 | +.544±.019 | +.586±.021 |
| Average constancy of differences in fleece weights | 18.3% | 29.6% | 34.3% |

It will be seen from Table 7 that as a rule the correlation involving the whole group of does is higher than either of the correlations of the two separate groups of does at the same shearing. This merely means that there are a number of permanent differences in fleece producing ability *between the two groups.* When only one group is considered at a time these differences do not affect the correlation because the does of one

group are all alike or nearly alike with respect to these differences, but when the two unlike groups are combined in one correlation table then these differences between them do affect the correlation to increase it. It is worth while to point out the practical bearing of this on the problem of selecting goats on the basis of fleece weights for increased mohair-production.

The more permanent differences there are in any group of goats, the more successful any method of culling based on correct principles will be, and conversely, the more uniform a flock already is, the less immediate improvement will result from culling. Grade Does 1-51 had already been culled by virtue of their having been selected one by one from a large flock at the time of their purchase. Consequently they were more uniform and their correlations were lower as a result of that uniformity. Grade does 52-154 were purchased without any individual selection and therefore were less uniform, their correlations were higher because there were more permanent differences between them, and culling would have resulted in proportionately more immediate improvement in them than in does 1-51. Culling the entire group of does 1-154 would result in proportionately still more improvement than culling either group by itself, but the cause of this would be that culling the entire group would be largely a process of sorting out again nearly all of does 1-51 into the better half of the flock. That differences in uniformity are the causes of the differences in the size of the correlations for the three groups is borne out by the fact that the average of the coefficients of variability for the six shearings involved in Table 7 is 20.7% for does 1-51, 26.4% for does 52-154, and 28.1% for the combined group of does 1-154.

Since culling will give better immediate results on flocks lacking in uniformity, it necessarily follows that goat-raisers whose flocks are less uniform than the groups of goats studied separately in this Bulletin will derive greater benefits from culling than the figures in this Bulletin would indicate, while those whose flocks are more uniform will derive less benefit. We have no exact data on which to compare the uniformity of the groups of goats which make up the Experiment Station flock with the uniformity of the average flock of goats in the state,* but it is the opinion of the authors that the different groups from the Experiment Station flock studied in this Bulletin are more uniform than the average flock of Angora goats found in this state. However, some goats differing in type are

*If any goat-raiser desires to know how the *uniformity* of his flock in respect to fleece weight actually does compare with that of the Experiment Station flock and therefore how far the results given in this Bulletin may apply to his flock, the authors will be glad to make the calculations and send him that information without charge provided he sends them the necessary data. Those data are the weights of all the fleeces produced by the goats about which he desires to know. For example the data may be given as follows: 1 fleece weighing 2.50 lbs., 3 fleeces weighing 2.75 lbs. each, 12 fleeces weighing 3.00 lbs. each, 11 fleeces weighing 3.25 lbs. each, etc. Weights should be accurate to a quarter of a pound or less, must not be averaged together, and must be of comparable individuals (that is, individuals of the same age, sex, and general breeding). It is desirable to have the weights of at least twenty-five or thirty fleeces, and fifty or more would give still more reliable results.

Calculation of the actual *coefficient of correlation* between the fleece weights of the same goats at different shearings will require more data but the authors will be glad to make that calculation for any goat-raiser who would care to take the data and send it to the authors at College Station. This would be still more accurate than a

kept in the Experiment Station flock for experimental purposes and it is probable that there are flocks of Angora goats which are more uniform than the Experiment Station flock.

The most important difference between the results obtained with mohair weights and the results obtained with wool weights (as discussed in Texas Bulletin 311) is that the differences in mohair weights are not so constant from shearing to shearing as the differences in wool weights. On theoretical grounds there could be two explanations for this. First, mohair fleeces may be influenced in weight much more by temporary environmental influences than wool fleeces are. Second, it may be that there are fewer hereditary factors influencing fleece weight in Angora goats and that the Experiment Station goat flock may have been hereditarily much more uniform than the Experiment Station flock of sheep. If the flock were perfectly uniform in heredity the only permanent differences in fleece weight must have been due to environment and if environment produced few permanent changes in fleece weight then the correlations would necessarily have been low. This second explanation is disproved as a complete explanation by two facts: first, there is nothing in the history of the flocks to support it; and, second, if it were true, the variability of the mohair weights within each group of goats would be less than the variability of the wool weights within each group of sheep. As a matter of fact the variability was actually greater within each group of goats than within each group of sheep. No detailed study of the amount of variability was made but the average of the coefficients of variability for the 44 different shearings of groups of sheep which consisted of twenty or more individuals was 15.23±33% while the average coefficient of variability for the 55 different shearings of groups of goats which consisted of 40 or more individuals was 22.81±0.37%. The difference is 7.58±.50%. Put into popular language this means that the sheep actually used in these studies showed only about two-thirds as much variability in their fleece weights as the goats did and that the difference is so great (more than fifteen times its probable error) that it cannot reasonably be

---

knowledge of the uniformity of his flock in telling the goat-raiser how much it would pay *him* to cull *his* flock. The data should be in some such form as the following:

| Goat No. | Fleece Weights | |
|---|---|---|
| | Spring 1925 | Fall 1925 |
| 1 | 4.25 | 4.0 |
| 2 | 2.75 | 3.0 |
| 3 | 3.0 | 3.75 |
| etc. | etc. | etc. |

The correlation can be calculated for as few as fifteen or twenty goats but it is hardly worth while to do it for less than forty or fifty, and still more would make the results more dependable.

supposed to be accidental, and a difference which would be almost as large would be sure to be found again if a similar experiment were repeated.

We have, then, established two facts: first there is greater variability among the weights of mohair fleeces than among weights of wool fleeces at a given shearing. Second, the weights of the wool fleeces are more constant from one shearing to another than the weights of mohair fleeces. Between these two facts there is no escape from the conclusion that temporary environmental forces have much more influence upon mohair fleece weights than upon wool fleece weights. We have not collected and analyzed enough data to know whether this greater variability in weight of the mohair fleece is due to a greater variability in its shrinkage per cent or to a greater variability in the actual weight of the scoured mohair, or to a combination of both.

The situation with respect to heredity and selection for heavy fleeces in Angora goats may be summarized as follows: A goat inherits the ability to produce a certain weight of mohair under ordinary environmental conditions. If the environmental conditions are better than the average, more mohair will be produced, but less will be produced if the conditions are below average. These environmental conditions may be different enough to influence very differently individual goats which are of the same age and sex and have even been allowed to browse in the same pasture during the same season. Therefore, selection for heavier fleeces strictly on the basis of the actual weights of fleeces produced will result in some mistakes although the correct decisions will outnumber the mistakes and some progress will be made toward heavier fleeces not only in the generation actually culled, but also in the offspring of that generation. Culling on the basis of fleece weights is better than no culling at all but it seems reasonable to suppose (although the data to prove it are lacking) that a man well-acquainted with Angora goats could, by observing the character, quality, length, and density of fleece and the extent to which the whole body is covered with mohair, cull a flock of Angora goats for increased mohair-production more accurately than can be done by actually weighing each fleece. The actual weight of the mohair fleece is not as accurate an index to the inherited ability of a goat as the weight of the wool fleece is to the inherited ability of a sheep because the weight of the mohair fleece is influenced much more by temporary environmental forces than is the weight of the wool fleece.

# PART III

## THE INFLUENCE OF AGE AND SEASON UPON THE WEIGHT OF THE MOHAIR FLEECES

It was possible to study individuality without taking either the effects of age or season into consideration, merely by using in any one correlation table only goats of the same age and sex which were sheared the same two seasons. It is not, however, possible to study the effects of age and season separately. This is obviously true because if shearing records of the same goats at different ages are used, they will also be influenced by differences in season, while, if we compare goats of different ages, the same year, their individual mohair producing abilities may be different. It is possible, however, to study the combined influence of age and season and, if the study is carried on with enough goats over a great many years, accurate knowledge can be secured of the exact effects of age and seasonal changes.

The first two shearings reported in this Bulletin (those for the spring of 1917 and the spring of 1918) were of twelve months' growth of mohair and were produced in a different locality and therefore it seems hardly fair to compare them with the later shearings although they are included in the tables and figures. The 1918 fall shearing of the foundation registered does consisted of only about five months' growth of mohair and therefore cannot fairly be compared with the later shearings. The shearings of the other goats in the fall of 1918, and all later shearings of all goats except the kids, consisted of six months' growth of mohair, varying not more than ten days from an exact six months in any case. Most of the kids were dropped in April or very late in March and therefore the kid shearing included on the average a little more than five months' growth of mohair. Thus we have ten successive six-month shearings suitable for comparison with each other and these provide sufficient data to answer most of the questions which may arise about the effects of age and season upon the weight of fleece. The effects of age upon the weights of wether fleeces are not completely revealed by these data because none of the wethers were kept past three years of age, but for economic reasons this point is not very important since not very many wethers are ordinarily kept on ranches past this age.

Table 8. The Influence of Age and Season on the Weight of the Fleece

(Weights are expressed in percentages of the first short spring shearing, which is the yearling shearing in all except the last four groups. The influence of individuality is excluded).

| Goats Included | Long Spring 1917 | Long Spring 1918 | Fall 1918 | Spring 1919 | Fall 1919 | Spring 1920 | Fall 1920 | Spring 1921 | Fall 1921 | Spring 1922 | Fall 1922 | Spring 1923 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade does 155-291..... | | | 33.3 | 100.0 | 162.9 | 95.4 | 130.6 | 115.7 | 113.7 | 96.3 | | |
| Grade does 418-684..... | | | | | 67.7 | 100.0 | 174.0 | 115.4 | 143.5 | 119.1 | 164.9 | 132.1 |
| Grade does 687-941..... | | | | | | | 52.2 | 100.0 | 150.2 | 99.1 | 135.9 | 123.5 |
| Grade does 943-1141..... | | | | | | | | | 79.1 | 100.0 | 178.3 | 130.0 |
| Grade does 1142-1178.... | | | | | | | | | | | 60.9 | 100.0 |
| Grade wethers 157-290... | | | 34.0 | 100.0 | 156.0 | 102.4 | 157.3 | 153.8 | | | | |
| Grade wethers 417-686.... | | | | | 71.9 | 100.0 | 189.6 | 170.5 | | | | |
| Grade wethers 688-942.... | | | | | | | 49.8 | 100.0 | | | | |
| Grade wethers 944-1139... | | | | | | | | | 80.6 | 100.0 | | |
| Grade wethers 1145-1179.. | | | | | | | | | | | 60.8 | 100.0 |
| Registered does 50-93..... | | | | | 48.5 | 100.0 | 159.2 | 109.1 | 132.1 | 104.0 | 145.5 | 115.2 |
| Registered does 103-150.. | | | | | | | | 100.0 | 190.5 | 139.5 | 180.3 | 158.8 |
| Registered does 145-225.. | | | | | | | | | 96.3 | 100.0 | 156.3 | 131.9 |
| Registered does 227-282.. | | | | | | | | | | | 68.1 | 100.0 |
| Foundation registered does | 186.4 | 210.3 | 93.8 | 100.0 | 111.6 | 86.7 | 106.5 | 93.4 | 95.1 | 85.3 | 84.0 | 73.2 |
| Grade does 1-51..... | | | 62.6 | 100.0 | 100.0 | 90.3 | 90.9 | 99.8 | 85.4 | 78.5 | | |
| Grade does 52-154..... | | | 83.9 | 100.0 | 111.8 | 98.6 | 101.1 | 96.5 | 94.3 | 84.1 | | |
| Grade does 292-416..... | | | 121.8 | 100.0 | 119.8 | 107.6 | 118.9 | 117.8 | 105.2 | 94.2 | 121.0 | 95.6 |

Table 9

The Influence of Age and Season on the Weight of Fleece
(Weights are expressed in pounds and the influence of individuality is not excluded)

| Goats included | Long Spring 1917 | Long Spring 1918 | Fall 1918 | Spring 1919 | Fall 1919 | Spring 1920 | Fall 1920 | Spring 1921 | Fall 1921 | Spring 1922 | Fall 1922 | Spring 1923 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade does 155—291 | | | .98 ± .02 | 2.97 ± .05 | 4.78 ± .07 | 2.92 ± .05 | 3.82 ± .07 | 3.36 ± .08 | 3.41 ± .07 | 2.89 ± .08 | | |
| Grade does 418—684 | | | | | 1.64 ± .02 | 2.42 ± .03 | 4.17 ± .05 | 2.78 ± .05 | 3.33 ± .06 | 2.94 ± .05 | 4.13 ± .11 | 3.31 ± .08 |
| Grade does 687—941 | | | | | | | 1.30 ± .02 | 2.53 ± .04 | 3.77 ± .06 | 2.51 ± .04 | 3.45 ± .09 | 3.14 ± .08 |
| Grade does 943—1141 | | | | | | | | | 1.38 ± .02 | 1.76 ± .02 | 2.97 ± .09 | 2.18 ± .07 |
| Grade does 1142—1178 | | | | | | | | | | | 1.27 ± .03 | 2.10 ± .06 |
| Grade wethers 157—290 | | | 1.19 ± .04 | 3.46 ± .06 | 5.37 ± .09 | 3.54 ± .08 | 5.36 ± .12 | 5.34 ± .10 | | | | |
| Grade wethers 417—686 | | | | | 1.77 ± .02 | 2.49 ± .04 | 4.74 ± .07 | 4.30 ± .05 | | | | |
| Grade wethers 688—942 | | | | | | | 1.30 ± .02 | 2.57 ± .05 | | | | |
| Grade wethers 944—1139 | | | | | | | | | 1.52 ± .03 | 1.91 ± .03 | | |
| Grade wethers 1145—1179 | | | | | | | | | | | 1.41 ± .05 | 2.33 ± .08 |
| Registered does 50—93 | | | | | 1.50 ± .05 | 2.80 ± .08 | 4.51 ± .13 | 3.15 ± .10 | 3.91 ± .13 | 3.21 ± .11 | 4.65 ± .14 | 3.60 ± .09 |
| Registered does 103—150 | | | | | | | | 1.91 ± .12 | 3.69 ± .14 | 2.75 ± .14 | 3.63 ± .19 | 3.17 ± .15 |
| Registered does 154—225 | | | | | | | | | 2.17 ± .05 | 2.25 ± .05 | 3.55 ± .07 | 3.00 ± .07 |
| Registered does 227—282 | | | | | | | | | | | 1.44 ± .06 | 2.37 ± .07 |
| Foundation registered does | 6.57 ± .16 | 7.36 ± .22 | 3.38 ± .06 | 3.51 ± .08 | 4.05 ± .08 | 3.07 ± .06 | 3.77 ± .07 | 3.30 ± .06 | 3.40 ± .07 | 3.00 ± .07 | 3.12 ± .07 | 2.83 ± .06 |
| Grade does 1—51 | | | 2.49 ± .07 | 3.99 ± .07 | 3.96 ± .08 | 3.55 ± .07 | 3.58 ± .09 | 3.86 ± .09 | 3.42 ± .10 | 3.11 ± .09 | | |
| Grade does 52—154 | | | 2.19 ± .05 | 2.61 ± .06 | 2.92 ± .05 | 2.78 ± .08 | 2.80 ± .08 | 2.58 ± .10 | 2.31 ± .17 | 2.07 ± .12 | | |
| Grade does 292—416 | | | 3.44 ± .05 | 2.83 ± .04 | 3.36 ± .05 | 3.20 ± .05 | 3.34 ± .05 | 3.30 ± .06 | 3.11 ± .06 | 2.80 ± .06 | 3.60 ± .20 | 2.98 ± .11 |

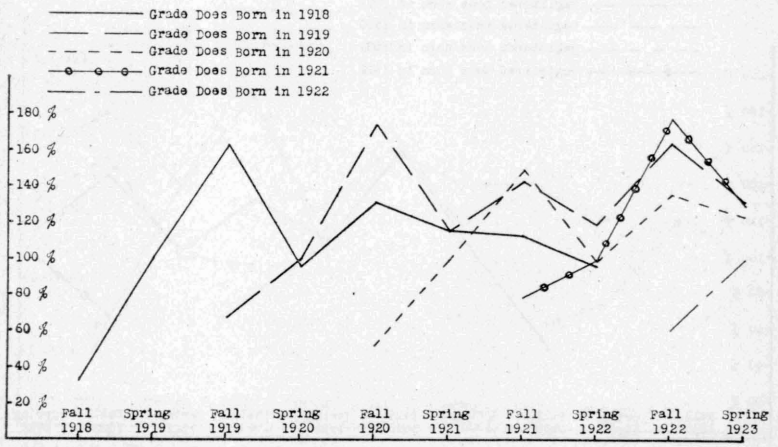


Figure 5. The influence of age and season on the weight of the fleeces produced by the grade does born at the Station. Weights are expressed in percentages of the weight of fleece produced by the same individuals at the spring shearing when they were one year old.

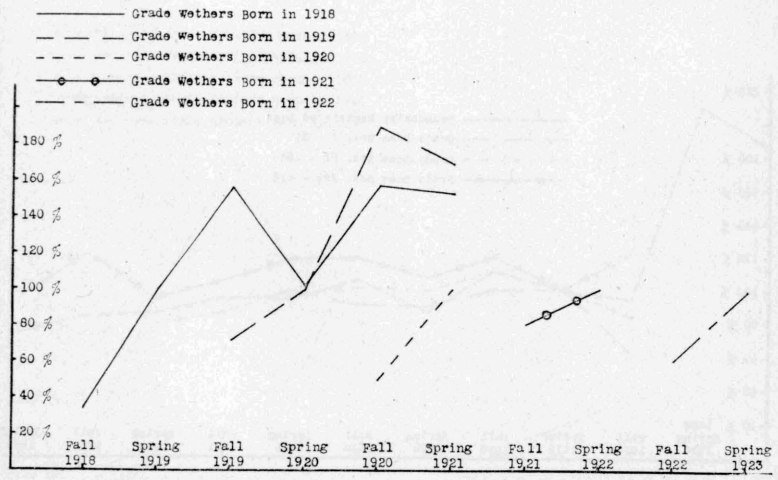


Figure 6. The influence of age and season on the weight of the fleeces produced by the grade wethers born at the Station. Weights are expressed in percentages of the weight of fleece produced by the same individuals at the spring shearing when they were one year old.

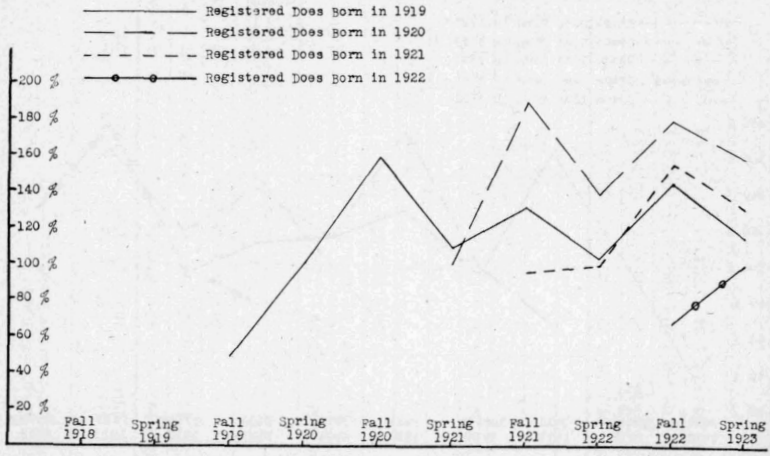


**Figure 7. The influence of age and season on the weight of the fleeces produced by the registered does born at the Station. Weights are expressed in percentages of the weight of fleece produced by the same individuals at the spring shearing when they were one year old.**

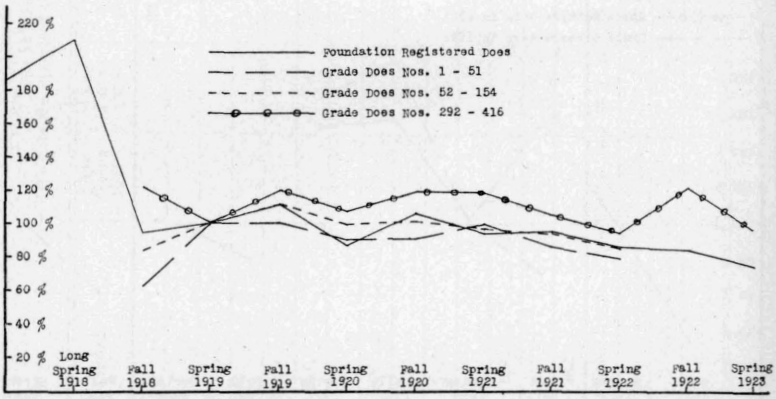


**Figure 8. The influence of age and season on the weight of the fleeces produced by the four groups of purchased does. Weights are expressed in percentages of the weight of fleece produced by the same individuals at the spring shearing of 1919. Grade does Nos. 292-416 were two years old and the others were older at the time of that shearing.**

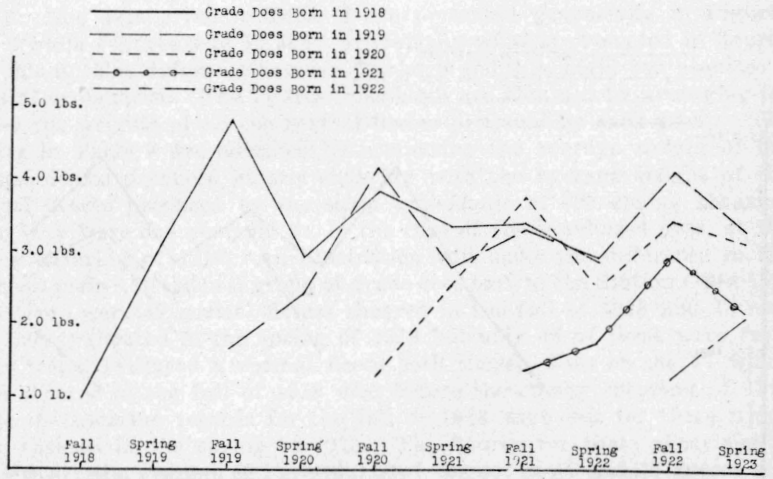


Figure 9. The influence of age and season on the weight of the fleeces produced by the grade does born at the Station. Data are taken from Table 9.

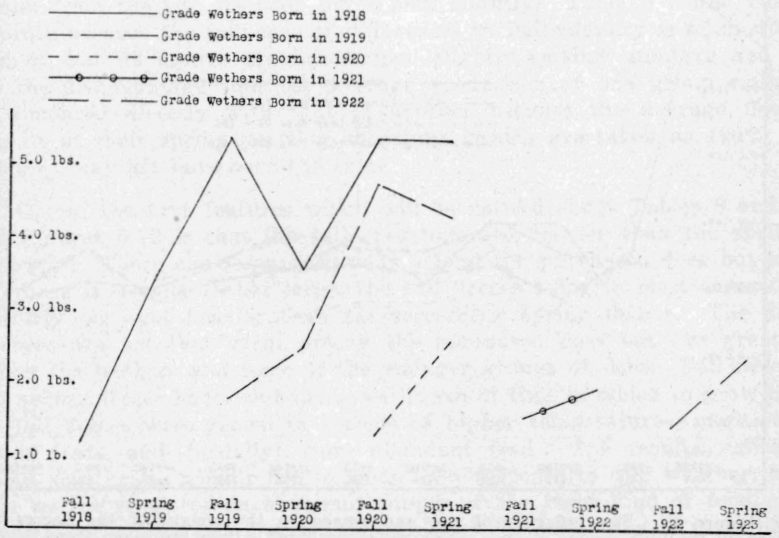


Figure 10. The influence of age and season on the weight of the fleeces produced by the grade wethers born at the Station. Data are taken from Table 9.

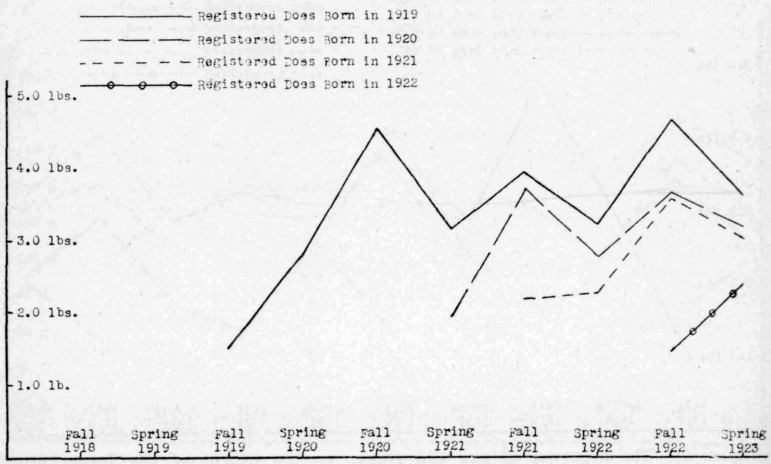


**Figure 11. The influence of age and season on the weight of the fleeces produced by the registered does born at the Station. Data are taken from Table 9.**

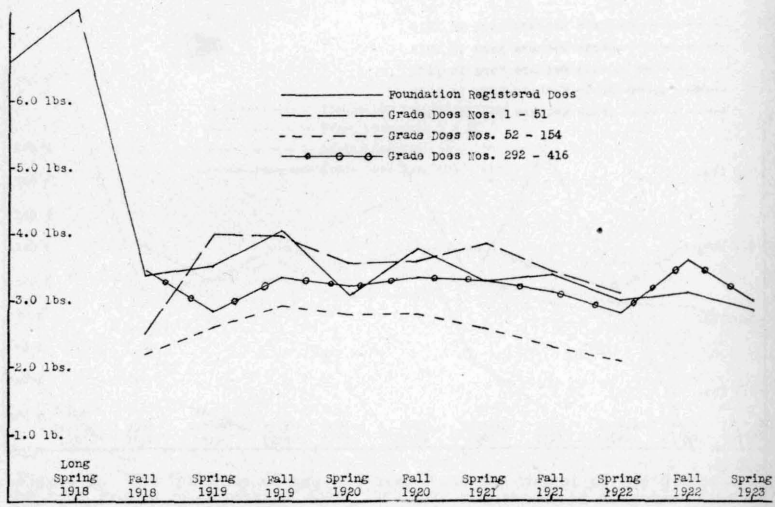


**Figure 12. The influence of age and season on the weight of the fleeces produced by the four groups of does which were purchased. Data are taken from Table 9.**

The combined influence of age and season upon the weight of fleece produced by the different groups of Angora goats is shown in Tables 8 and 9. The data given in Table 8 are presented graphically in Figures 5 to 8 while Figures 9 to 12 show graphically what is presented in figures in Table 9. The difference between Tables 8 and 9 is slight but requires a word of explanation. The figures in Table 9 are obtained by averaging together the weights of *all* the normal fleeces produced by each group. The figures in Table 8 are obtained by comparing the average weight of the normal fleeces produced at any shearing with the average weight of the normal fleeces produced by *the same individuals* at the spring shearing when they were one year old or, in the case of the purchased does, at the spring shearing of 1919. An illustration will make the difference in the methods plain: In the first group of grade does born at the Station (Nos. 155-291) there were 47 normal fleeces sheared in the fall of 1918 and 48 normal fleeces sheared in the spring of 1919 but only 45 of these were from goats which produced a normal fleece both times. Two of the 47 which were sheared in the fall of 1918 died before the spring shearing of 1919 while the shearing records for the fall of 1918 were lost for three which were sheared in the spring of 1919. The figures for these shearings in Table 9 are the average of the weights of the entire 47 and 48 fleeces respectively, but the figures in Table 8 are a comparison of the averages of the 45 fleeces which came from the goats which produced a normal fleece at both shearings. When the irregular records are of fleeces of average weight both methods will give the same result, but when the irregular records are of unusually heavy or unusually light fleeces the results will be slightly different. It will be seen from the Tables and the Figures that the results from the two methods differ only slightly. Table 8 is the more accurate because the influence of differences in individuality is eliminated from it, but its figures are based upon slightly smaller numbers and it has the disadvantage that the average production of one group cannot be compared directly with that of another because the average fleece weights at their spring yearling shearings (which are taken as 100% in Table 8) may not have been the same.

One of the first features which will be noticed about Tables 8 and 9 and Figures 5-12 is that the fall shearings are heavier than the spring shearings. There are some exceptions among the purchased does but the difference is usually rather large, the fall fleeces being in most cases ten to thirty per cent heavier than the succeeding spring fleeces. The differences are not that great among the purchased does but are greater among the wethers and some of the younger groups of does. Fall fleeces and spring fleeces had about the same length of time in which to grow but the fall fleeces were grown in periods of higher temperatures, more succulent feeds, and (usually) more abundant feed. The results indicate that a goat grows mohair not so much as a response to cold weather, but more as the result of an abundant supply of the right kind of food. It is possible that the fall fleeces have a higher shrinkage due to their having been grown in a warmer season and therefore containing more sweat

and yolk, but to offset this there is the fact that the goats were dipped during the periods when their fall fleeces were being grown and this would probably have tended to wash out enough sweat and yolk to lower the shrinkage noticeably. A study of the shrinkage of fall and spring fleeces of wool and mohair is being made at the Wool Scouring Plant of the Texas Agricultural Experiment Station at College Station but not enough data have been collected to serve as the basis of any conclusions as yet. However, it does not seem possible that a difference in shrinkage can entirely explain the difference in the weights of fall and spring fleeces since the shrinkage of a mohair fleece is ordinarily from ten to twenty percent, whereas many of the average fall fleeces exceeded the average weight of the following spring fleeces by more than thirty percent. Therefore, it is clear that more actual clean mohair was usually produced at the fall shearing than at the spring shearing. Abundant food of a good quality seems to be more important than low temperature in promoting the growth of mohair. It should be added that, from the time they were two years old, most of the grade does raised one or two kids each year. The kids were dropped after the spring shearing and weaned before the fall shearing (the shearing dates were near March 20th and September 20th each year), and therefore the effects of suckling these kids should fall entirely on the fall shearing of their dams rather than on the spring shearings. This probably is a complete explanation of the greater difference found between the spring and fall shearings of wethers than between the spring and fall shearings of mature does.

The effect of sex is very marked, the average weight of fleece produced by the wethers being greater than that produced by the grade does of the same age and breeding at every shearing except one. In that one (the kid shearing of the grades born in 1920) the average fleece weight is exactly the same (1.30±.02). The difference in the average weights of fleeces produced by does and wethers does not become a large one, however, until they are two years old, that is, until the does begin producing kids. Whether barren does would produce as large fleeces as wethers was not determined because there were so few barren does in the Station flock.

The effect of age is very marked and very great for the first three shearings but after that there seems to be very little change due to age, at least until extreme old age is reached. Extreme old age may be the explanation for the decreasing fleece-weight of the foundation does at the last three shearings, since the very youngest of them were five years old and most of them were eight or more at the time of the 1923 spring shearing. The first or fall kid shearing is very light, averaging only 58.6% of the second or spring kid shearing for the grade does, 59.4% for the wethers, and 71.0% for the registered does. Even these figures (taken from Table 8) are a little higher than normal because of the very light shearing in the spring of 1922 (to be discussed later), which makes the kid shearing in the fall of 1921 appear larger on the percentage basis. In no case is any later shearing as light as the kid shearing.

The second or spring kid shearing is not as a rule quite equal to the average later production of the goat. There are eighteen fair comparisons between second or spring kid fleeces and subsequent spring fleeces and in only three of them does the second or spring kid fleece out-weigh the later one. This means that as mohair-producers goats are not quite mature at one year of age.

The goat reaches its maximum capacity as a mohair-producer in the fall when it is one and a half years old. At least this is true of the does but only one group of wethers was kept long enough to be sheared in the fall when they were two and a half years old and that group sheared practically the same amount in both its yearling fall shearing and its two-year-old fall shearing. One group of does (registered does 50-93), according to the method of figuring used in Table 9, sheared slightly more in the fall when they were three and a half years old than in the fall when they were yearlings, but according to the more accurate method used in Table 8 the fall yearling shearing for this group was larger than any later shearing for it.

The influence of age upon fleece weight thus seems almost identical in Angora goats and in sheep, as discussed in Texas Bulletin 311. In both cases the fleece production during the first year of life is less than normal; in both cases maximum fleece production is attained by the females during their second year of life; in both cases there are indications, although not enough data for absolute proof, that the wethers can continue to produce as heavy fleeces later in life as they do in their second year, and, finally, in neither case do the effects of extreme age become very marked, if evident at all, until the animals reach at least seven or eight years of age.

The data on which this present Bulletin is based are too few to justify the establishing of very exact figures as to the effect of age on fleece-weight, or to permit the working out of an exact equation which would show the relation between age and fleece-weight. Data on many more groups of goats for different years will be needed for that. However, the data in this Bulletin (as presented in Table 8) are the most complete data available and therefore they have been averaged in Table 10 and presented graphically in Figure 13. The probable errors of those averages will furnish an approximate indication of their accuracy. No probable errors could be calculated for the last two ages of wethers because the figures for those ages are based upon only one group of goats. No attempt was made to weight the figures from Table 8 in proportion to the number of goats which each figure concerned because inspection of Table 8 shows that there was more variation from season to season than there was between different groups at the same seasons. For example, all kid fleeces were unusually light in the fall of 1918 and all kid fleeces were unusually heavy in the fall of 1921, etc. Therefore, it seemed best to treat each season as a unit regardless of the number of fleeces upon which its average was based. The grade does and the registered does were treated as separate units. The percentages in the last four lines in Table 10 were

obtained indirectly from the figures in Table 8 for the three purchased groups of grade does, by assuming that the fleece weights of the purchased groups in the spring of 1919 bore the same relation to their second or spring kid fleece weights as the average fleece weight of the station-raised does (when they were the same age as the purchased does were in the spring of 1919) did to their second or spring kid fleece-weight. It is the authors' belief that these average figures represent rather accurately the effect of age upon fleece-weight except in the case of the last two figures for wethers and the last figure for does, which are almost certainly too low.

Table 10. The Effect of Age Upon Average Fleece-Weight. (Expressed in percentages of the yearling spring fleece. Figures taken from Table 8 and averaged).

| Age | Does | Wethers |
|---|---|---|
| Kid | 63.3±4.3 | 59.4± 4.9 |
| Yearling Spring | 100.0 | 100.0 |
| Yearling Fall | 167.3±3.3 | 172.8± 8.0 |
| Two-year-old Spring | 117.2±4.0 | 136.5±16.2 |
| Two-year-old Fall | 144.5±5.6 | 157.3 |
| Three-year-old Spring | 124.2±5.6 | 153.8 |
| Three-year-old Fall | 141.4±8.2 | |
| Four-year-old Spring | 114.5±5.7 | |
| Four-year-old Fall | 120.6±2.2 | |
| Five-year-old Spring | 118.1±2.2 | |
| Five-year-old Fall | 121.7±5.8 | |
| Six-year-old Spring | 104.7±2.3 | |

One interesting result caused by a combination of the effects of age and season is to be observed in the case of the kids born in 1921. A severe drouth began in June 1921 and continued until late in March 1922. The effects of the drouth began to be evident in the pastures by mid-summer of 1921 and it will be noticed that the 1921 fall shearing was an unusually light shearing for all goats *except the kids*. The kids had been weaned only about a month before that shearing and had evidently been receiving almost all their food from their mothers' milk and therefore had been protected from the effects of the drouth as shown by the fact that their fleeces were unusually heavy that fall as compared with other kid fleeces. That it was their mothers' milk which protected them from the effects of the drouth is shown by the fact that the following spring their fleece-weights were unusually low for yearlings. They had gone through the fall and winter of the drouth without any milk from their mothers, since they had been weaned before the fall began, and therefore they felt the effects of the drouth and resultant scarcity of feed just as the other goats did. This is an excellent illustration of the way young

animals are guarded naturally against effects of an unfavorable environment until after they are weaned, their mothers even drawing on their own reserve food-supply for some time before decreasing very much in milk yield.

It will be seen by comparing these Tables and Figures with those in Texas Bulletin No. 311 that the mohair weights are more subject to increase or decrease with unfavorable seasons than the wool weights are. Thus, although all the groups of goats do not agree at every shearing, it will be seen that in general among the fall shearings, that for the fall

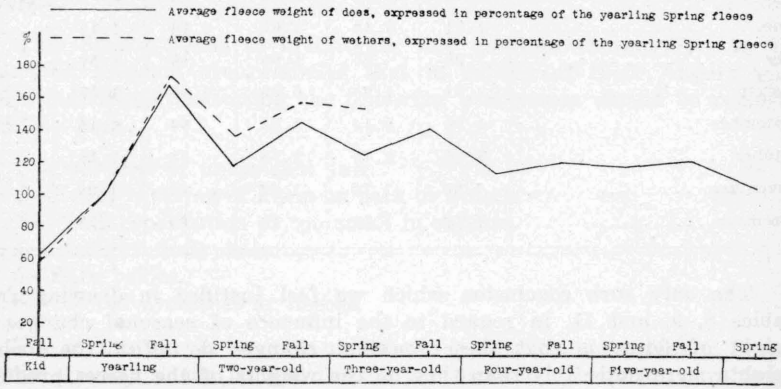


Figure 13. The effect of age upon average Fleece weights. (This is a graphical presentation of the data shown in Table 10).

of 1922 is unusually heavy, while those for the fall of 1918 and the fall of 1921 are below the average. Also, among the spring fleece weights, that for the spring of 1922 is distinctly low and that for the spring of 1923 is high except in the case of the purchased does, which were getting old by that time. There was a short but rather severe drouth from May to October in 1918 and a long severe one from early June 1921 to March 1922 and it will be seen that the light shearings are the three following those drouths, that is, the shearings for the fall of 1918 and fall of 1921 and spring of 1922. The fleece weight for the spring of 1920 is slightly below the average and it is interesting to note that the February and March rains (on which depends so much of the early growth of weeds upon which the goats feed) totalled only 0.76 inches for that season. Of course rainfall is not the only factor controlling the amount of feed which is produced in that region, but on this one ranch under a rather uniform system of management and carrying about the same amount of livestock from year to year, the amount and distribution of the rainfall are the most important factors governing the production of feed. The amount and monthly distribution of rainfall as officially recorded at Substation No. 14 during the first five years for which the records were taken are given in table 11.

Table 11. Monthly Rainfall in Inches, Texas Agricultural Experiment Station, Substation No. 14, Sonora, Texas

| | 1918 | 1919 | 1920 | 1921 | 1922 | 1923 |
|---|---|---|---|---|---|---|
| January | .... | 2.28 | 2.33 | 1.13 | .65 | 1.55 |
| February | .... | 1.45 | .36 | 1.49 | .10 | 3.98 |
| March | .... | 2.15 | .40 | 3.17 | 2.13 | 2.59 |
| April | .... | 2.49 | .32 | .84 | 5.19 | 4.09 |
| May | 3.24 | 3.58 | 2.59 | 4.76 | 1.03 | .... |
| June | 1.21 | 5.48 | 4.67 | 2.66 | 4.14 | .... |
| July | .00 | .95 | 1.96 | .45 | 1.30 | .... |
| August | .61 | 1.98 | 6.09 | 1.05 | 3.23 | .... |
| September | 1.90 | 9.14 | 2.24 | .64 | 2.14 | .... |
| October | 5.50 | 2.44 | 2.78 | .38 | 3.18 | .... |
| November | 1.90 | 1.16 | 1.62 | .40 | 1.93 | .... |
| December | 1.70 | .51 | .15 | .30 | .05 | .... |

The only sure conclusion which we feel justified in drawing from Tables 8, 9, and 11, in regard to the influence of seasonal changes on weight of fleece is that these seasonal changes do affect the mohair weights more noticeably than they do the weights of the fleeces produced by sheep. Drouths, presumably because of the scarcity of feed which results from them, cause a distinctly lighter mohair fleece to be produced.

## OTHER CONSIDERATIONS IN CULLING ANGORA GOATS

The amount of yolk or grease that should be carried in the fleece of mohair is at the present time a debatable point among the Angora goat breeding fraternity in the United States. A number of scouring tests conducted at this Station have shown that mohair fleeces have shrunk as low as seven percent and as high as twenty-eight per cent.

Mohair buyers representing eastern houses in Texas have not up to the present time made a practice of purchasing mohair on a clean basis. Usually kid hair is sold at a certain stipulated figure while all grown hair regardless of clean yield generally goes at a flat price.

Under the present system of marketing, the breeder producing the mohair with a heavy shrinkage reaps a larger profit than the one who produces a fleece possessing plenty of character and quality but with a lighter shrinkage.

Mohair manufacturers do discriminate, however, against fleeces containing a large amount of kemp, since it cannot be dyed evenly. Therefore, even though there is still some question as to the amount of yolk or grease that a mohair fleece should carry, the breeder should reject all bucks carrying a considerable amount of kemp on back or breech. The

authors' experience has been that there is a tendency among the extremely oily-fleeced bucks to show an abundance of kemp, although in a few highly improved flocks producing the heavier shrinking fleeces, kemp has been found to be almost entirely absent.

Due to the fact that first-quality kid hair possesses more quality than any other grade of mohair offered on the market, and brings the highest price, it is only reasonable then to suppose that the hair from the grown goat which most nearly approaches the kid hair in character, quality, and condition should be the most valuable kind of hair for the breeder to produce.

This Station plans to investigate this question thoroughly. In the meantime, breeders are reminded that in culling of their Angora goat flocks, individuals possessing the following weaknesses should be removed from the flock:

1—Over-shot or under-shot jaw.
2—Heavy covering of kemp on back or breech.
3—Weak constitution or too small in carcass.
4—Straight fluffy hair.
5—Bare bellies.
6—Colored eyelashes or fleeces.

The mohair should be quite uniform in quality from shoulder to breech and the ringlets should be well formed and distinct. Uniformity in length of mohair over the various parts of the body is important.

It is evident that culling must be done at shearing time or just before, if it is to be practical for the producer of mohair as well as for the breeder of registered goats. By marking the undesirable goats with special wool paint as soon as they are sheared, this culling can be done without keeping any extra records. All that it will require is a little extra paint and the time of the man who is doing the culling in the shearing shed. It is not necessary to cull out exactly half of the flock (as has been mentioned in the illustrations in this Bulletin). If only one-fourth of them are culled out the benefits will still be large enough on the average to pay handsomely for the trouble of culling. On the other hand the breeder of registered goats may want to pick out only a small portion of his flock from which to raise his best breeding stock. Each man can make his culling standard high or low to suit his own situation. The essential point is that such culling will, on the average, steadily raise the standard of the flock and its results will be profitable enough to justify its becoming part of the customary practice of mohair-producers.

## SUMMARY

1. Texas contains more than half of all the Angora goats in the United States. The principal source of revenue from these goats at the present time is the mohair which they produce; hence the importance of finding out how to breed and manage goats so that more and better mohair will be produced.

2. This Bulletin presents and analyzes a large amount of data with respect to fleece weight. The importance of other characteristics than weight of fleece (for example, fineness, luster, condition, freedom from kemp, etc.) is not underestimated but those things are not discussed in this Bulletin merely because of the lack of any such large amount of data dealing with them as is available on the subject of weight of fleece.

3. The data on which this Bulletin is based consists of the individual weights of the twelve-month fleeces shorn at Substation No. 7, Spur, Dickens County, in the spring of 1917 and spring of 1918 and of the six-month fleeces shorn at Substation No. 14, Sonora, Sutton-Edwards Counties, from the fall of 1918 to the spring of 1923, inclusive. In all there were 1166 different goats which were sheared at least twice, some of them being sheared as many as twelve times. A number of others which were sheared only once are included in Table 9 in the study of the influence of age and season on the weight of fleece.

4. Individuality is defined, for the purpose of this Bulletin, as the permanent differences (with respect to the weight of the fleece which they produce) between individual goats of the same age and sex and of the same general breeding. The influence of individuality on fleece weight is studied by means of correlation tables.

5. There are a total of 302 such correlation tables and the average value of the coefficients of correlation is $+.415 \pm .008$, which means that, on the average, 17.2% of the differences in the weight of fleeces produced by goats similar in age, sex, and general breeding, are permanent throughout the lifetime of those goats and therefore are subject to selection.

6. There is a great deal of variation in the size of the correlation. The largest negative correlation is $-.346 \pm .130$ and the largest positive correlation is $+.861 \pm .030$. There is a slight but probably not significant tendency for the correlations involving the largest numbers of individuals to be the highest.

7. Individuality is much more important with some groups of goats than with others, and, consequently, culling will be more profitable with some groups than with others.

8. Fall fleeces from the same goats tend to resemble each other in weight and spring fleeces from the same goats tend to resemble each other in weight more closely than fall fleeces tend to resemble spring

fleeces in weight. There is some indication of a hereditary basis for this, since it was much more pronounced in the grade does and wethers than in the registered does. Since fall shearings are heavier than spring shearings, this makes it evident that the fall shearing is better than the spring shearing as a time at which to cull goats for increased mohair production.

9. Shearings separated by short intervals of time resemble each other in weight more closely than those separated by longer intervals, when allowance is made for the greater resemblance in weight between different fall shearings and between different spring shearings than between fall and spring shearings.

10. Permanent differences in fleece weight show up less accurately at the first shearing than at later shearings, and show more accurately at the fall yearling shearing than at any other age. Therefore, culling will be most effective if done at the fall yearling shearing.

11. Seasonal conditions seem to have little or no influence upon the size of the correlations between fleeces produced at different times. There is some slight evidence that such correlations are highest when they concern seasons when production is highest but this evidence is not conclusive.

12. In flocks less uniform than the Experiment Station flock, culling would be more immediately effective than in the Experiment Station flock. In flocks more uniform than the Experiment Station flock, culling would be less effective. Goat-raisers may find out how the uniformity of their flock compares with that of the Experiment Station by sending the necessary data to the Experiment Station.

13. Environmental conditions cause much more variation in the weight of mohair fleeces than they do in the weight of wool fleeces.

14. Fall fleeces are heavier than spring fleeces. The difference varies quite a great deal but the fall fleece is ordinarily ten to thirty per cent heavier than the succeeding spring fleece. The difference is greater than this in the case of the wethers and less in the case of mature does which are raising one or two kids.

15. Wethers produce heavier fleeces than does but the difference is not very great until after they are two years old; that is, until the does begin producing kids.

16. The effect of age is very marked on the first three shearings only. The first or fall kid shearing is very light, averaging only sixty to seventy per cent as heavy as the second or spring kid fleece. The second or spring kid shearing is a little lighter than later spring shearings, thus indicating that goats have not quite reached maturity in fleece-production at one year of age. The fall yearling fleece is the largest one the does produce. It is also very large in the case of the wethers but their

later fall shearings may possibly be still larger; the data are not conclusive on that point.

17. The effects of old age on fleece weight do not become marked until the goats are at least six or more years old.

18. The effects of age on fleece weight are very similar in sheep and goats. In both sheep and goats, fleece-production is not up to normal during the first year of life; in both, the females attain maximum fleece-production during the second year of their lives and in later years produce slightly less than in the second year but more than in the first year until extreme old age; in both, there is some evidence but not conclusive proof that the wethers can in later years continue to equal or exceed the fleece-production of their second year; in both, the effects of old age on the fleece-production of the females are not evident until the females are at least six or more years old.

19. Drouths and the resultant scarcity of food lower the weights of fleeces from Angora goats more than the weights of fleeces from sheep under the same conditions.

20. On the basis of these facts it is recommended that every mohair-producer should adopt a regular policy of culling his flock. Such a policy rightly carried out will result in an increase in the average weight of fleece which his flock produces and an improvement in the character and quality of the mohair produced.

## REFERENCES ON ANGORA GOATS

Black, W. L., 1900. A New Industry or Raising the Angora Goat and Mohair for Profit. Keystone Printing Co., Ft. Worth, Texas.

Chapline, W. R., 1919. Production of Goats on Far Western Ranges. United States Department of Agriculture, Bulletin No. 749.

Schreiner, S. C. C., 1918. The Angora Goat. Longmans and Co., New York.

Williams, G. P., 1921. The Angora Goat. United States Department of Agriculture, Farmers Bulletin No. 1203.